Submerged Prehistory

Edited by

Jonathan Benjamin
Clive Bonsall
Catriona Pickard
Anders Fischer

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Preface

Jonathan Benjamin, Clive Bonsall, Catriona Pickard and Anders Fischer

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This volume is concerned with those parts of the prehistoric archaeological record that now lie under water. Most of the sites and finds described were inundated as a result of the global sea-level rise of some 120 m that occurred during the Final Pleistocene and Early Holocene (see Figure below). Throughout this remarkable transformation of global geography, vast tracts of habitable terrain vanished, engulfed by the world's oceans. Discoveries from inland waters have also been included to highlight the archaeological significance of prehistoric lacustrine and riverine sites. Examples are presented from Europe, Western Asia, and North America. The material included in this volume is predominantly Mesolithic and Neolithic in age, but we also include examples from the Palaeolithic, as well as the Chalcolithic (Copper Age) and Bronze Age.

Although the past few decades have witnessed significant development and growth of this specialized field, the study of *Submerged Prehistory* is still in its infancy. Countless inundated prehistoric sites, from marine, brackish and freshwater environments worldwide, have yet to be discovered and studied. We envisage the coming decades will see such material introduced into the discourse of world prehistory, and we hope this volume will serve as inspiration for future research and heritage management.

Of the 25 peer-reviewed chapters in this volume, 13 were presented during a session at the *European Association of Archaeologists'* annual meeting held in Riva del Garda, Italy, in September 2009. Entitled *Underwater Archaeology and the Future of Submerged European Prehistory*, the session was intended to showcase recent finds and the methods used in their discovery and investigation, and to stimulate discussion in the wider context of European and world prehistory. The burgeoning interest in this topic is reflected in the number of scholars not present at the EAA session who have subsequently contributed chapters to the volume.

The EAA session and subsequent publication also coincided with the establishment of COST Action TD0902 SPLASHCOS, to the mutual benefit of both. SPLASHCOS – Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf (http://php.york.ac.uk/projects/splashcos/) – is a four-year research network funded by COST, aimed at the international coordination and promotion of new research, and has provided funding toward the production of this volume.

We express our great appreciation to the specialists from many countries and disciplines who have acted as anonymous peer reviewers; their valuable input has significantly improved the overall content of the volume. We also acknowledge the generous sponsorship provided by the following organizations:

- Römisch-Germanische Kommission des Deutschen Archäologischen Instituts, Frankfurt;
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- Wessex Archaeology Ltd

Editorial note on radiocarbon dates and water depth

Throughout this book calibrated radiocarbon dates are usually expressed in terms of 'cal BC', but occasionally 'cal BP'. Uncalibrated radiocarbon dates (and dates produced by other scientific dating methods) are presented in terms of 'BP' or 'ka BP'. Historical dates are presented in years 'BC'.

Water depth has a considerable significance in relation to chronology as well as practical accessibility of archaeological material. In this volume depth is always reported in relation to local mean sea level (MSL).

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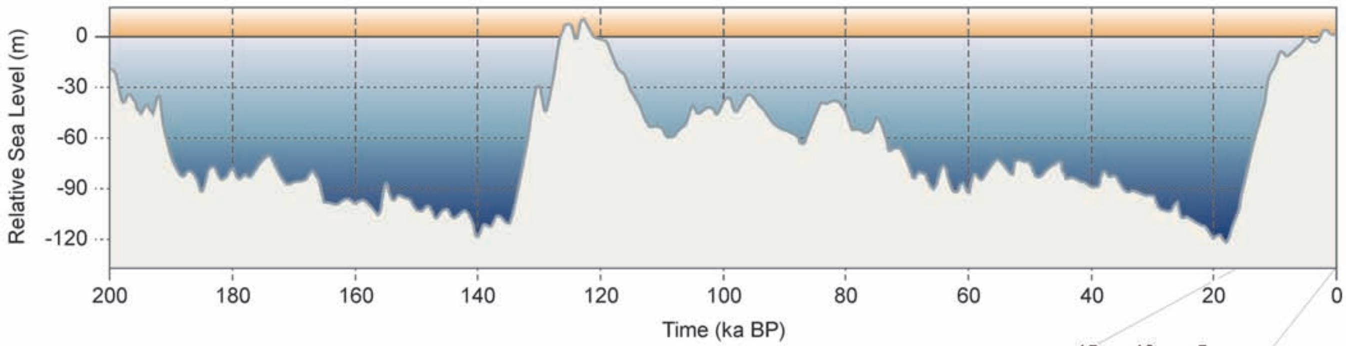
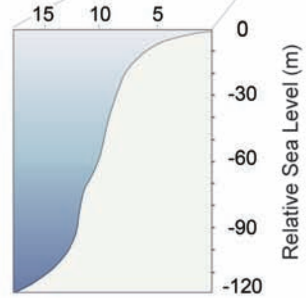


Two generalized curves of global relative sea-level change. Above: a curve for the last 200,000 years (based on stable oxygen isotope data as a proxy for eustatic sea level; data from Lisiecki and Raymo 2005). Below: eustatic sea-level rise since the Last Glacial Maximum (based on the Barbados coral data; redrawn from Fairbanks 1989). The spread of humans around the world took place mainly during periods when vast stretches of today's sublittoral zones were dry land and available for habitation. The Pleistocene (and the last 'Ice Age') ends and the Holocene begins at c. *10,000 BP/11,600 cal BP (Drawn by K. Brandon and J. Benjamin)*



1

Ertebølle Canoes and Paddles from the Submerged Habitation Site of Tybrind Vig, Denmark

Søren H. Andersen

*The Late Mesolithic Ertebølle culture submerged settlement at Tybrind Vig was one of the first sites to demonstrate the extraordinary preservation conditions for prehistoric organic remains that exist beneath the shallow waters of the western Baltic Sea. A wide range of previously unknown types of wooden tools and artefacts was found, and among the most spectacular finds were four ornamented paddles which display a new type of art with patterns carved in shallow relief into the surface of the wood and filled with a brown material. The new motifs are softer with sinuous and fan-shaped lines and they differ from the geometric style seen on artefacts of antler, bone, and amber. The reason that some paddles were ornamented was probably that they were used as individual or group identifiers. Several dugout canoes were also excavated, and the site demonstrated for the first time how common these boats might have been. Of these, Tybrind I was the most spectacular because of its length (*c. *10 m) and thinness (2–4 cm). All the canoes were made of long, straight tree trunks of lime (*Tilia *sp.) and had a hearth of clay inside the boat at the stern. Chopping and wedge marks point to the use of adzes and wedges in their construction, while fire was not used to hollow out the vessels. Modern estimations point to a carrying capacity of 6–8 people with equipment. The fact that such canoes combined the social and subsistence activities of society and widened the radius of economic activities greatly made them of extreme importance for the coastal population.*

Keywords: Tybrind Vig, Ertebølle, Late Mesolithic, submerged, settlements, organic preservation, art, ornamented paddles, ash wood, dugout canoes, lime wood

Introduction

The excavation of the Late Mesolithic settlement of Tybrind Vig took place between 1972 and 1983 (Andersen 1985, 1987a). The site demonstrated the extraordinary preservation conditions for organic remains that exist on such settlements, and a wide range of new types of wooden tools and artefacts, decorated paddles, dugout canoes, residues of charred food on pottery, textiles, and artefacts of bone and antler, were recovered.

The Tybrind settlement is located on the seafloor off the west coast of the island of Fyn in central Denmark. Owing to geological factors, the Late Mesolithic coastlines of this part of Denmark are now submerged, and the settlement – originally situated on the prehistoric shore – is today found at a depth of *c.* 2–3 m below sea level and *c.* 200–300 m out from the present-day coast (Fig. 1.1). The settlement belongs to the Late Mesolithic Ertebølle culture of southern Scandinavia and is radiocarbon dated to *c.* 5400–4000 cal BC. The occupation took place during a period of rising sea level, which caused a gradual displacement of the settlement. Later erosion of

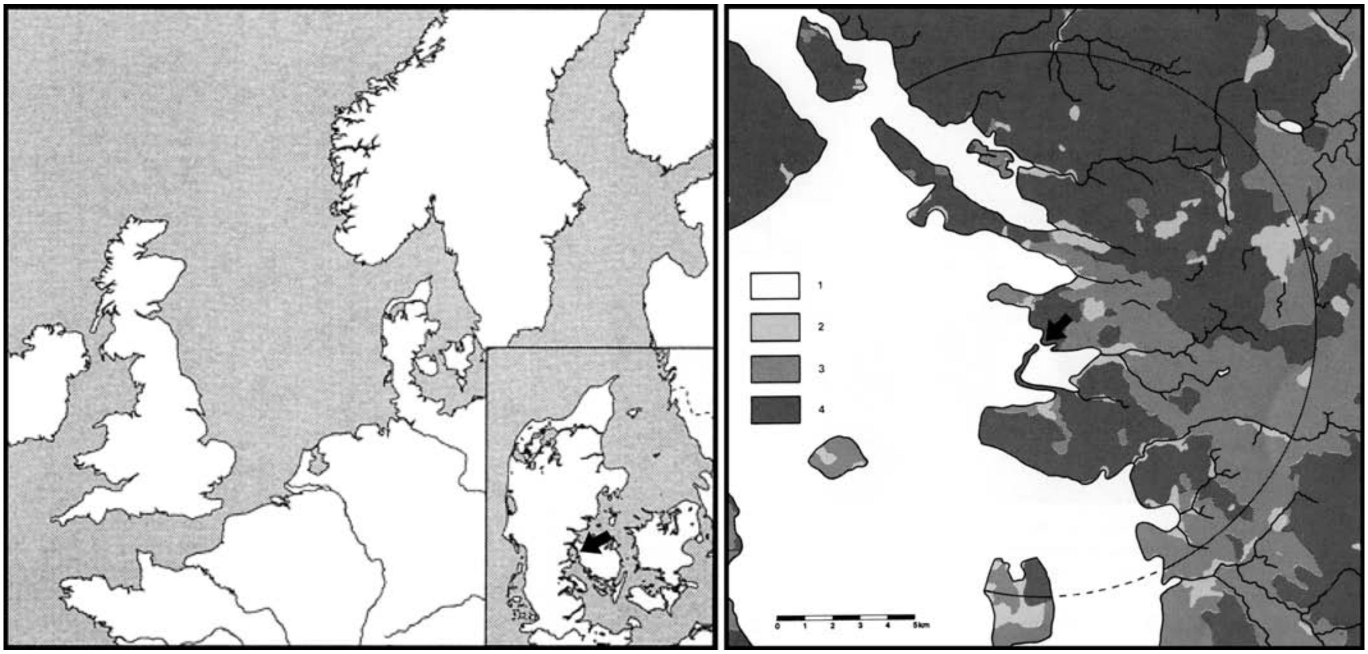


Figure 1.1: The location of Tybrind Vig (indicated by arrows) on the west coast of the island of Funen. 1 sea and freshwater lakes; 2 waterlogged areas; 3 sandy soils; 4 other soils (Drawn by L. Hilmar and E. Morville)

the seabed resulted in parts of the settlement area proper, belonging to the latest (and highest lying) occupation phase, being eroded away, while the deeper, still *in situ* layers, were protected. Typically the latter are located in the wet, soft, calcareous and anaerobic marine layers (gyttja) off the settlement site. These sediments have offered some of the best preservation conditions ever encountered in the west Baltic area. Cultural deposits follow the prehistoric coastline over a distance of *c.* 100–130 m, with a width of *c.* 20 m, and consist mainly of settlement debris that ended up in the soft, marine deposits adjacent to the settlement proper. The topographic position and settlement layout are identical to what we know from excavations of contemporary settlements on dry land, e.g. Ertebølle (Andersen and Johansen 1987), Bjørnsholm (Andersen 1993) and Meilgård (Andersen 2000b). Although Tybrind Vig was a technically difficult underwater excavation, a total area of *c.* 180 m^2 was systematically excavated, sections recorded, and various different samples taken for scientific and environmental analysis.

At the very beginning of the excavation a well-preserved wooden paddle was found (Fig. 1.2). Previously, this type of paddle was known only from the Ertebølle site of Rüde LA 2 (in the Satrup bog) in northern Germany (Schwabedissen 1960; Hartz and Lübke 2000). Originally the Satrup finds were described (and interpreted as spades), implying that they were a primitive type of agricultural implement (Schwabedissen 1960; Troels-Smith 1960; Steensberg 1980, 1985). Based on tests of the use of these objects as ploughing implements this interpretation was later refuted (Andersen 1984: 24), and the objects have since been interpreted as paddles (Andersen 1984; Ravn 1993; Hartz and Lübke 2000: 382).

Later, several more paddles were found at Tybrind Vig, and one of the great surprises was that four of these showed decoration (Figs 1.4–8). Suddenly we were confronted with a new art style on a new material (wood) – distinctly different from that known hitherto from the Mesolithic in Europe where all the ornamented objects were of amber, bone, antler, and occasionally also stone and ceramics, and showing a strong geometrical style (Andersen 1981; Płonka 2003). In all, 14 examples of three different types of wooden paddles were excavated from Tybrind Vig (Fig. 1.3). Of these, three are almost complete, while the others are either detached blades or comprise other characteristic parts of paddles.

Type A (Satrup type) (Fig. 1.3a–b), has a triangular heart-shaped blade that is perpendicular to the shaft (Schwabedissen 1960; Andersen 2000a). The paddles were made in one piece from single wooden planks from cloven tree trunks. The wood species have been identified in seven cases as ash (*Fraxinus* sp.), and this is also the case with one of the paddles from northern Germany (Hartz and Lübke 2000: 379). The tree trunks had a diameter of 20–40 cm and sapwood

was selected. The paddle blades vary between 15 cm and 26 cm in length, 15–26 cm in width and between 1 cm and 1.5 cm in thickness. The edges are sharp or slightly rounded and the cross-section (of the blade) is plano-convex. The surface is even and smooth and bears fine marks and scratches from its manufacture. The length–width dimension of the paddle blade is approximately 1:1. The shaft is straight with a length ranging from 80 cm to 120 cm and terminates in a cornet-shaped apex. One of the German paddles has a somewhat longer shaft with a length of *c.* 163 cm (Hartz and Lübke 2000: fig. 3.1). At the handle end of the shaft the cross-section is round to oval, whereas further down at the junction with the blade it tapers slightly and has a more semi-circular or triangular cross-section. The transition from shaft to blade is sharp and the edges of the shoulders are thin and sharp. From the upper edge of the blade, the outline continues into rounded shoulders and downwards towards the lower apex, which is broad and rounded, the edges being straight or slightly convex and also become thicker and more compact. The shaft continues down 1–3 cm over one side of the blade forming a foot or tongue. This feature is very characteristic of this type of Ertebølle paddle (Schwabedissen 1960: fig. 8d). In profile, the grip is therefore asymmetrical relative to the paddle blade, i.e. only one side of the shaft is in line with the surface of the paddle blade (Fig. 1.2).

These paddle blades had two weak points, the transition between the shaft and the blade, and the blade itself, which often splits longitudinally (following the course of the tree rings). In two Danish cases (one from Tybrind Vig [Andersen 1984: fig. 4a] and one from Haldrup Strand – unpublished) attempts have been made to repair this kind of damage by drilling small holes on both sides of a split in order to bind the two parts together. A similar type of repair is known from one of the paddles from Satrup (Hartz and Lübke 2000: fig. 3, nos 1–3).

There are now records of this type of paddle (and variants) from several Danish Ertebølle settlements (mainly in western Denmark), e.g. Tybrind Vig and Ronæs Skov (Andersen 2009: fig. 99), Flynderhage (Andersen 1984: fig.10), Haldrup Strand, and Teglgård (for a distribution map, see Andersen 2009: fig 102). Variants of this type are also known from a few sites on Zealand, e.g. Halsskov (Myrhøj 1997: 164, fig. 5), Store Lyng, Åmosen (unpublished), and

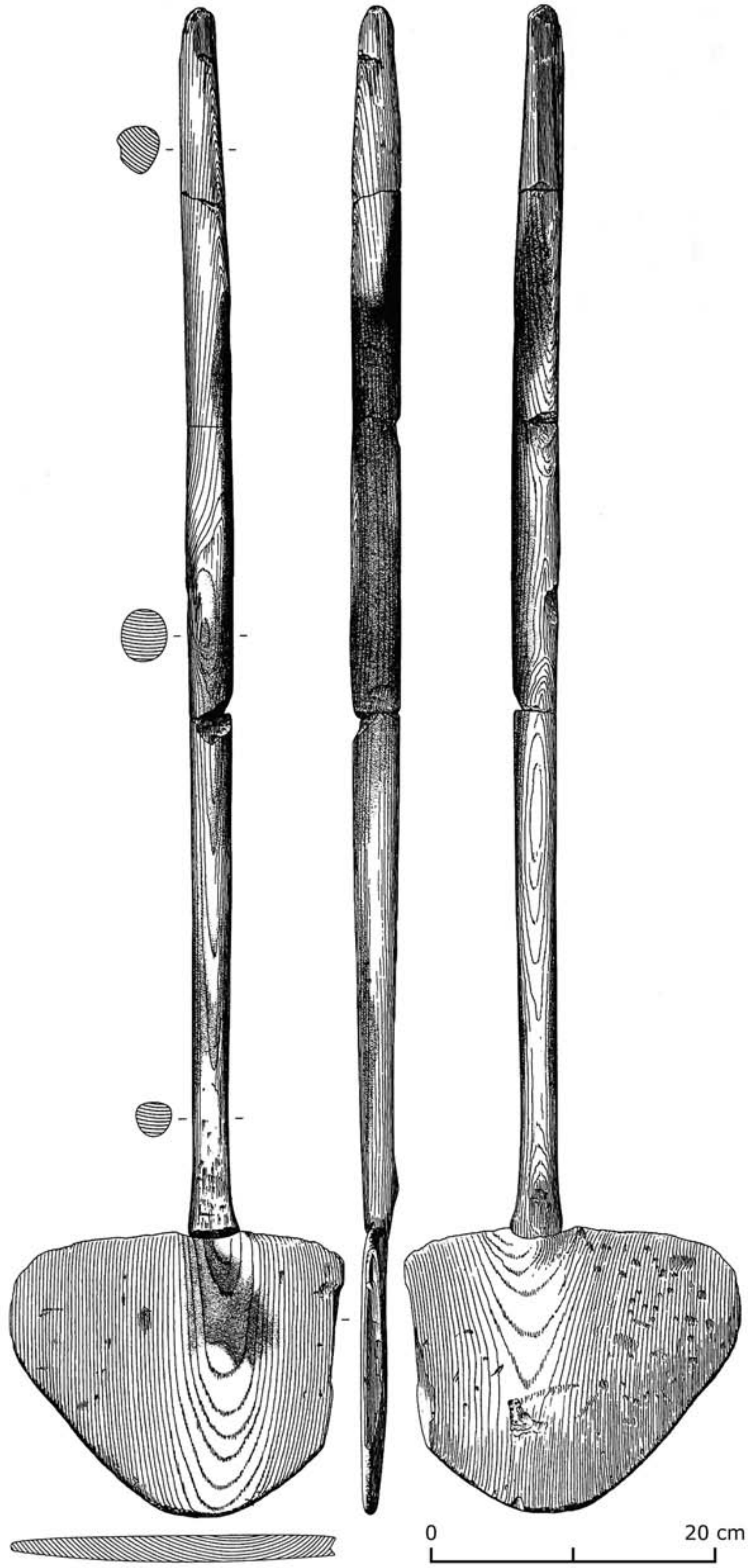


*Figure 1.2: The first find of a complete paddle from Tybrind Vig. The specimen is an example of the small variant without ornamentation. Note the charred areas on the handle and the blade. All the Tybrind paddles were made from planks of split ash trunk (*Fraxinus *sp.) (Drawn by Orla Svendsen)*

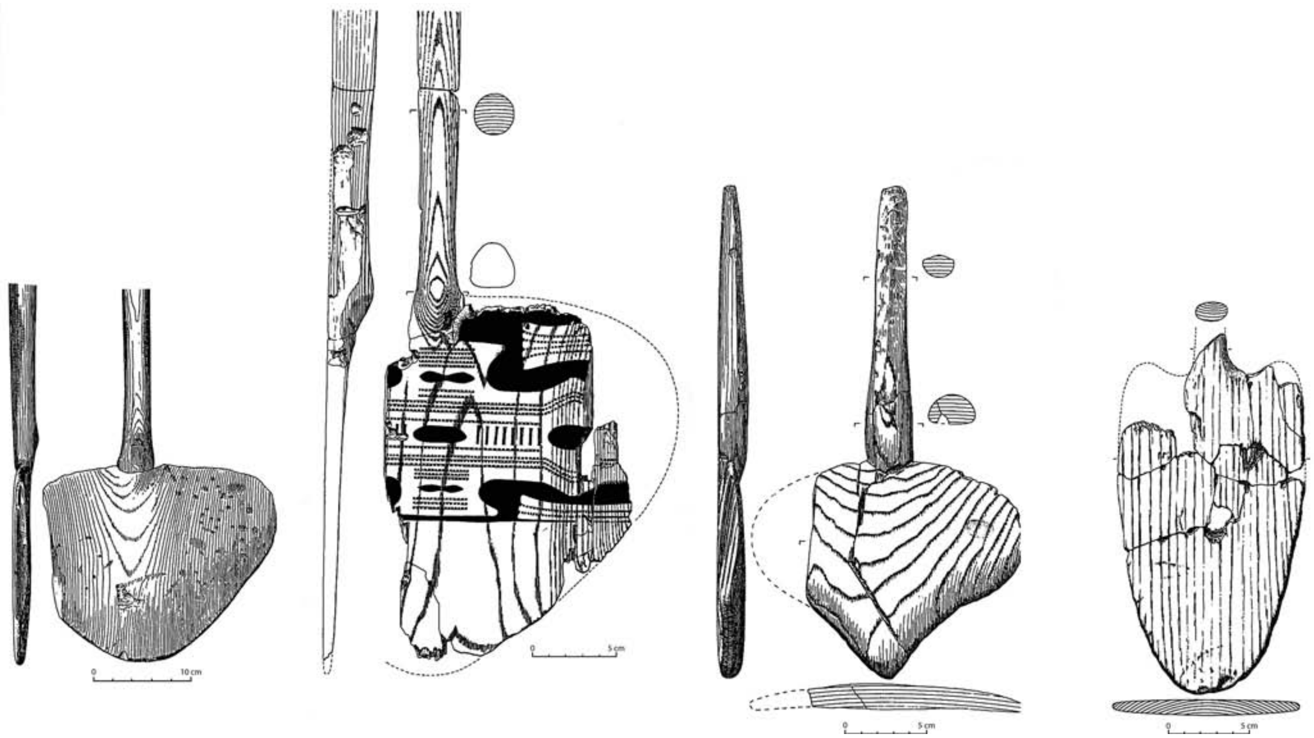


Figure 1.3: Schematic representation of the three types of Ertebølle paddles from Tybrind Vig: 3a small variant of the Satrup type, cf. Figure 2; 3b larger Satrup type with decoration; 3c Tybrind type; 3d Ringkloster type (Drawn by O. Svendsen, F. Bau and E. Morville)

Maglemosegårds Vænge (unpublished). From northern Germany the type is known from the inland Ertebølle site of Rüde LA 2 and the coastal site of Rosenhof (Hartz and Lübke 2000: 379, fig. 1).

The Tybrind Vig type B paddle (Fig. 1.3c) is known from Tybrind Vig where three examples have been found (Andersen 2000a: 10–13). Other find sites include Tudsehage (Lotz 2000: 11, fig. 3.2), Gamborg Fjord (Andersen 2009: fig. 102), and Agernæs (Jæger 1998, 2000). This type is also made from a single piece of wood from close to the pith of the trunk of ash (*Fraxinus* sp.). As was the case with type A, the shaft is displaced relative to the blade. It continues a few centimetres down over the surface of one side of the blade and is in line with the other (Fig. 1.3c). Like the Satrup type, the blade is symmetrically positioned laterally relative to the shaft. The paddle blade itself is short, broad, and heart shaped. It is quite distinct from the Satrup type in having concave edges that meet in a short, thick point, the outermost part of which is worn and compacted. The upper edges of the blade are slightly convex and continue in rounded shoulders; downwards, the edges become thick (0.5 cm) as well as concave. In cross section this type of blade is plano-convex in such a way that the side in line with the shaft is flat (as with the Satrup type). The most important differences between this type and the Satrup paddles are that these are shorter and smaller than the latter and are also relatively heavier, more robust, more concave, with thicker rounded edges (Figs 1.8 and 2.8). The blade of this type measures 12–15.5 cm in length, 16–20 cm across, and 1.2–1.7 cm in thickness.

The type C, or Ringkloster-type, paddle (Fig. 1.3d) has an oval outline, and the blade is flat on both sides and has sharp or slightly rounded edges. It is symmetrical along its length axis and is characterized by symmetrical notches on both sides of the base of the shaft/handle in order to give a good grip during paddling. The raw material is ash wood (*Fraxinus* sp.). This type is known from Tybrind Vig, Ronæs Skov (Andersen 2009: 116, fig. 99) and Ringkloster (Andersen 1998: fig. 33). The paddles measure 15–20 cm in length, 11.5–15 cm across, and *c*. 1 cm in thickness.

The decorated paddles from Tybrind Vig

The first example of an ornamented paddle blade appears to have been an old, worn-out example that ended up in the refuse layer by the settlement (Fig. 1.4, left). Parts of both sides of the blade were split and broken off; an attempt had been

made to repair the split and a small hole close to the split is presumably a trace of this repair. The paddle also exhibits several other fractures and pieces of the edge are missing in several places. The sides are completely even and smooth and do not show traces of deeper scratches, grooves or wear marks. The shaft is well preserved and has a length of 1.16 m. The blade measures *c*. 14 cm in length today, but must originally have had a length of *c*. 30 cm, a width of 30–35 cm, and a thickness of *c*. 1 cm.

The ornamentation is found on the convex side, where the design covers the upper two-thirds of the blade. However, owing to degradation and erosion, it is impossible to tell whether, originally, the other side of this paddle was also ornamented, although this seems likely (see below). The composition covers the width of the blade and is horizontal; it is symmetrical about both the blade's long and transverse axes (Fig. 1.4). The motifs consist of a mixture of geometric designs and softer, sinuous bands, balancing the effect of strict composition with the motifs. The pattern is built around a transverse field with a horizontal rhombic figure (in the centre), bordered symmetrically by vertical parallel bunches of lines and horizontal ellipses. This field is framed by a single row, and then three transverse parallel rows, of small dots. Parallel to these are sets of two, three and five short, parallel rows of dots, framing horizontal spectacle figures. Above and below, the whole pattern is completed with elegant sinuous and fan-shaped lines resembling birds' tails (Fig. 1.4, left).

As to the individual motifs the dominant one comprises small, round dots set close together and forming short lines, or slightly curved or angular bands. The short, horizontal lines are seen in groups of five, two and three plus three, while the longer bands occur singly as straight lines or parallel groups of three plus three. Other motifs are vertical bunches of thin, parallel, closely-spaced lines, ellipses, rhombic and spectacle-shaped figures, and large fields of sigmoid and sinuous bands, surrounding fields with fan-shaped rows of dots (Fig. 1.4).

All in all the ornamentation shows a strong resemblance to a human face (Fig. 1.5 and below). Today, the ornaments appear in faint relief with associated slightly depressed areas

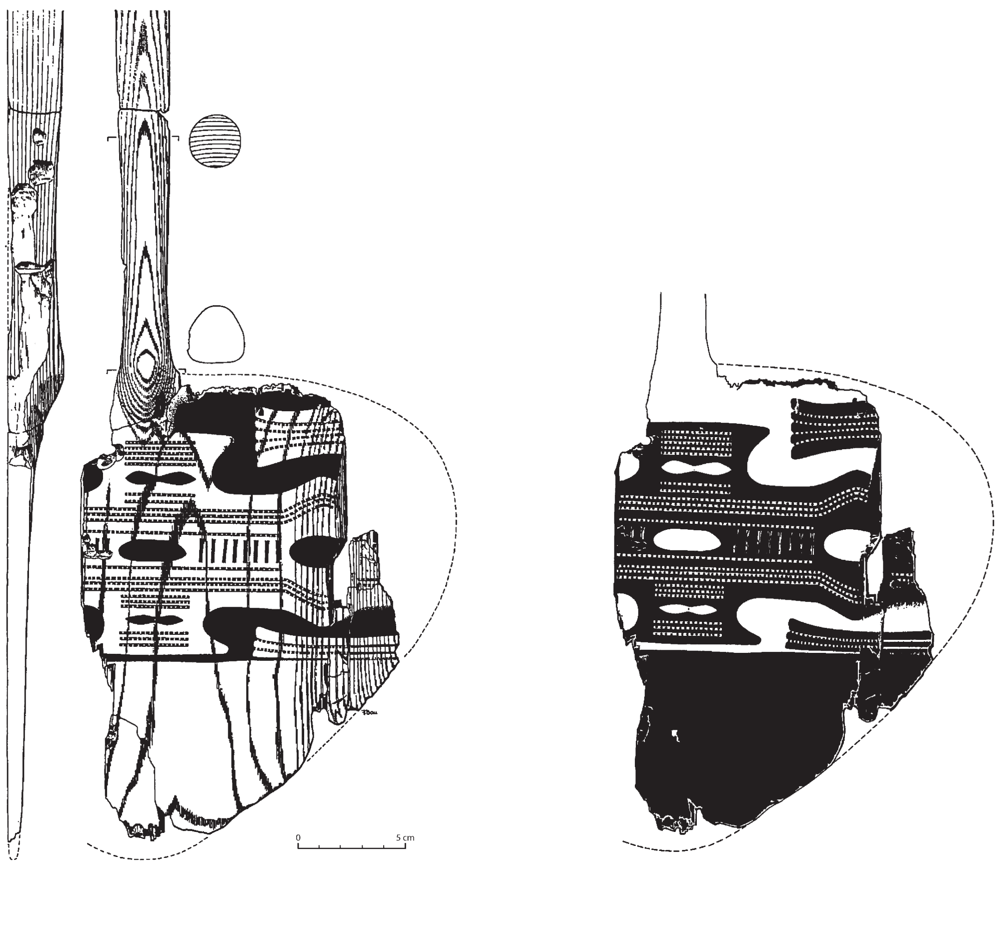


Figure 1.4: Paddle with decoration on one side of the blade only (left); the parts inlaid with pigment are here marked in black. The pattern reproduced in negative (right) (Drawn by F. Bau)

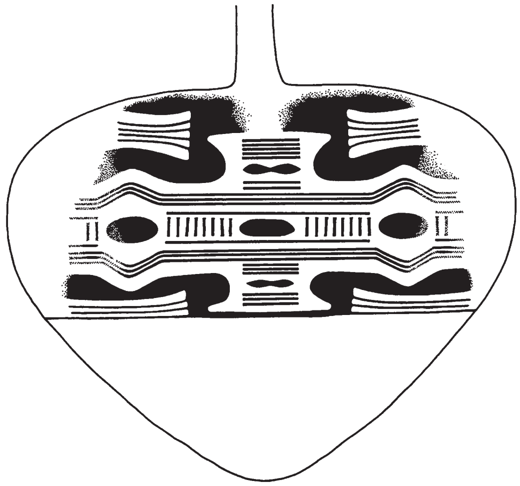


Figure 1.5: Reconstruction of the design of the paddle in Figure 4 (Drawn by F. Bau)

in the otherwise smooth, even surface of the paddle; the depressions are 0.5–1.5 mm deep. On recovery, there was a dark brown material (pigment) in the depressed ornamentation, which gave a clear contrast to the surrounding, still pale yellow ash wood. Despite various chemical analyses, it has not been possible to identify the nature and composition of the (colouring) substance, but exposure to ultraviolet light prompted strong bright fluorescence in the ornamented sections, revealing the presence of a binding agent and possibly also a pigment likely to have been an iron compound (e.g. ochre).

A similar paddle is ornamented on both sides, apparently of the same composition and motifs as on the first paddle (Fig. 1.6). Unfortunately, the surface of this paddle is not very well preserved, which is why the ornamentation can only be discerned in patches. These ornaments appear as slightly depressed areas for the inlaying of pigment into the surface. The composition is horizontally structured and covers the upper two-thirds of the blade sides (Fig. 1.6). This example is important as it proves that at least some of the paddles had ornamentation on both sides of the blade. Additionally, as both the composition and motifs correspond to those of Figure 1.4, this suggests that the ornamentation was a fixed, common feature of some of these paddles and therefore also reflects a particular type of artistic expression in wood. The paddle blade measures *c.* 25 cm in length, *c.* 26 cm in width, and is *c.* 1.5 cm thick.

Another two paddles of the Tybrind type display ornamentation (Figs 1.7–8). One shows decoration on both sides (Fig. 1.7), while the other has preserved ornamentation on one side only (Fig. 1.8). On the first example, the ornamentation is well preserved on one side, while the other is more decayed. The ornamentation is strictly symmetrical about the blade's longitudinal axis, and is again a mixture of geometrical figures and softer, sweeping bands (Fig. 1.7). The pattern is built up around a central field of two crescent-shaped motifs surrounded by a large biconvex figure, flanked by horizontal bands filled with small ovals, subrectangular figures, and fields with rows of small quadrants. Below are broad, elegant, curved transverse bands, boomerang-like bands and bands filled with small squares (Fig. 1.7). At the top are two almond-shaped figures on each side of the longitudinal axis, which is

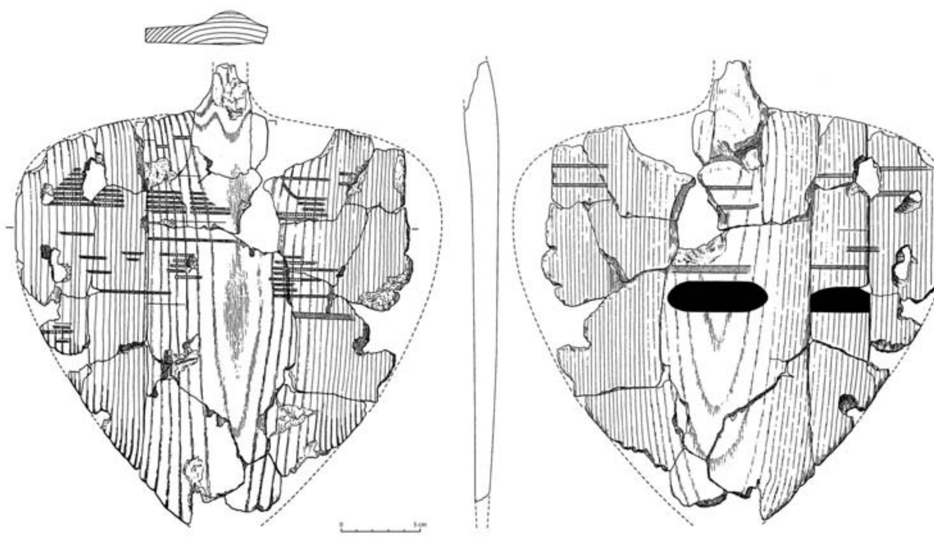


Figure 1.6: Paddle with ornamentation on both sides (Drawn by Orla Svendsen)

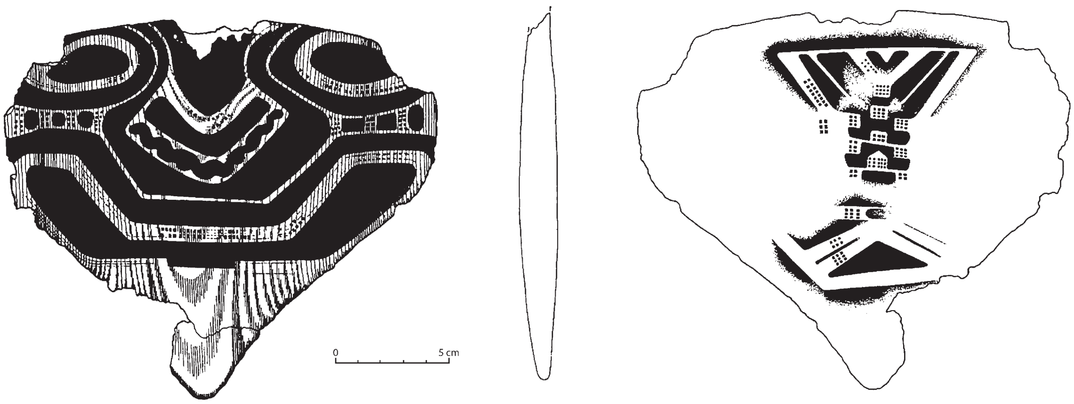


Figure 1.7: Paddle with ornamentation on both sides. The carved areas are marked with black (Drawn by E. Morville)

a drooping-nose like figure. Below are broad, elegant, curved, transverse bands – forming a mouth-like design. The composition covers three-quarters of the surface of the side, and beneath, it is terminated by elegant, transverse, sweeping bands filled by rows of dots. The whole pattern on this paddle blade is – like the motifs shown in Figures 1.4 and 1.5 – highly reminiscent of a stylized human face.

The ornamentation on the other side is only preserved in the central part of the paddle. The composition is symmetrical about the longitudinal axis. The motifs on this side are geometric in the form of triangular, V-shaped and horizontal bands and rectangles filled with rows of small rectangular dots. These bands appear to run across the blade. This paddle measures *c.* 16.5 cm in length, *c.* 19 cm in width, and *c.* 1 cm in thickness.

The fourth ornamented paddle is represented by slightly less than half of a blade that has been split along the longitudinal axis (Fig. 1.8). On recovery, there was ornamentation on only one side, probably due to the fact that only this side was well preserved. Again, the ornamentation covers the upper two-thirds of the blade. The composition is a series of horizontal, transverse bands and figures, of which some are already known from the other paddles, while others are completely new. The central part is filled by a large oval, and above and below are bands of three to four thin, parallel, horizontal series of rectangles, small, closely-spaced semi-circles, and horizontally arranged series of small ovals. Of these patterns, the horizontal oval is seen on all the other paddle blades, whereas the other motifs are characteristic of this particular paddle. The motifs are, to a great extent, reminiscent of the pattern of enamel on the occlusal surface of a worn molar of, for example, a deer. The motifs on this paddle are so fine and delicate that, in most cases, they could only have been stamped onto the surface. That stamping was used is apparent from the fact that the individual sets of motifs are slightly displaced relative to one another, presumably because the stamp was not placed exactly in the correct position each time (Fig. 1.8). This paddle blade measures *c.* 23 cm in length, *c.* 10 cm in width (in its present state), and *c.* 0.75 cm in thickness.

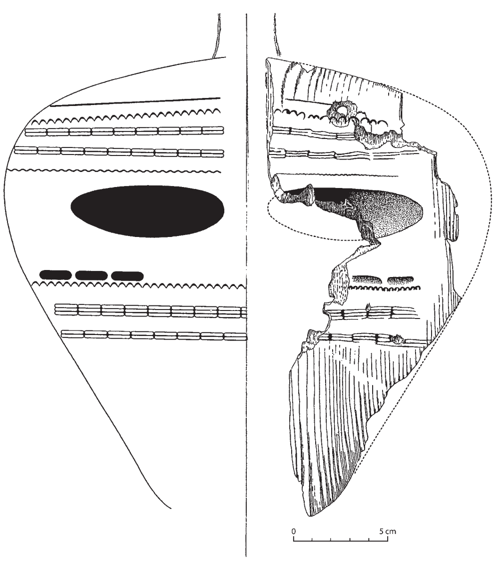


Figure 1.8: Fragment of paddle with decoration on one side only (right). Reconstruction of the design of the paddle (left) (Drawn by E. Morville and L. Hilmar)

Composition

The composition of the ornamented paddles is symmetrically organized around the longitudinal and transversal axes of the paddle blade. The designs cover the upper two-thirds of the blade and are mainly arranged in a horizontal manner. Although each paddle bears its individual patterns and motifs, some designs such as ovals,

lines with small dots or rectangles, and sinuous bands are common. The ornamentation is carved (perhaps also stamped in some cases) into the surface of the wood and stands out in shallow relief, while the depressed areas have been filled with a dark (black/brown) substance.

It is significant that, out of the four ornamented paddles, at least two are identical in size, composition and ornamentation. In this way it has been documented that these are unlikely to be unique, special cases but are, conversely, a more common feature of this type of artefact and probably also of other important types of wooden artefacts.

A comparison of the ornamented and non-ornamented paddles of the Satrup type establishes that the two decorated paddles (Figs 1.4 and 1.5) deviate from the others of this type in being larger. They are 25–30 cm in length and 25–30 cm in width, while the unornamented examples only measure 15–26 × 15–26 cm. Because of the unique character of these ornamented paddles, some effort has been made to discover the way in which the designs were produced. Relevant to this is a question concerning the ornamentation itself, as it appears today: does this reflect the original pattern or are the depressed areas a consequence of a possible secondary disintegration of the surface of the wood? If, for example, the whole of the surface of the paddle blade had been covered by a layer of paint or tar in which the pattern was then scratched, would this part of the surface automatically be more exposed to subsequent disintegration and decay than the remainder of the surface? If so, this would lead to the production of a negative of the actual pattern, which would then appear as shown in Figure 1.4 (right), whereas the positive pattern would appear as in Figure 1.4 (left).

Several possibilities for the production of the designs can be considered: carving, stamping, or corrosion into the surface of the wood. The even surface of the whole blade argues against corrosion, which leaves the two other possibilities. Most evidence points toward carving as the procedure used. Even today, the depressed areas of the surface show a darker colour than the surrounding, and it is obvious that the purpose of the relief work was to enable inlay of a dark colouring material into the surface of the wood to improve the artistic effect of the design and to accentuate and emphasize the ornamental effect. An identical technique is well known from several other patterned Ertebølle objects made from other raw materials, for instance antler, bone, and amber (Andersen 1981).

Figure 1.9: Modern replica of the paddle shown in Figure 1.4. The motifs have been carved into the surface using a small flint implement (Photo: Moesgård Museum)

All in all, our observations suggest that the ornamented paddle blades appeared originally as shown in Figures 1.4–8. The patterning was probably carved into the surface of the wood with a flint tool. Modern experiments with making replicas of the paddles have demonstrated that it is easy to produce such ornaments by carving in fresh wood (Fig. 1.9).

Dating

Several ^{14}C determinations and stratigraphic information indicate that the patterned paddles from Tybrind Vig belong to the middle and younger Ertebølle culture, *c*. 4800–4200 cal BC. This is some centuries later than the paddles from Satrup in Schleswig, which have been dated to the period *c*. 5400–4700 cal BC (Schwabedissen 1994: 370). However, the Satrup dates may be unreliable given the lack of documentation of the provenance of the samples and their association with the paddles (S. Hartz, pers. comm.).

Other Ertebølle paddles with ornamentation

In light of the fact that ornamentation was detected on four paddle blades, the obvious question arises as to whether all paddles were originally decorated? A thorough investigation

of all the other paddles and fragments shows, however, that this was *not* the case and that the absence of ornamentation is unlikely to be *exclusively* a consequence of preservation conditions.

Two other finds of Ertebølle paddles with designs are known, but they are clearly different from the paddles from Tybrind Vig. From Flynderhage, in east Jutland, there is a paddle with black painted ornamentation on one side of the blade (Fig. 1.10; Gabrielsen 1953; Andersen 1984: 23). It is made of ash wood (*Fraxinus* sp.); the black colouring matter has been chemically analyzed, which shows it to be a sort of 'tar oil'. The design, which is symmetrical along the longitudinal axis, covers the lower half of the blade and consists of a large triangle, above which there are four or five thin and slightly curved, horizontal lines.

From the Rüde LA 2 site in northern Germany, a paddle of Satrup type has decoration on both sides in the form of carved bundles of thin, diagonal lines that enclose a large rhomboid figure in the centre of the blade (Hartz and Lübke 2000: fig. 3, nos 2–3). A closer investigation of these lines indicates that they could also have had an inlay of a brownish material, which is not preserved. However, the latter two ornamented paddles clearly differ from those from Tybrind Vig, where the designs are more curved, have a more complex composition, and are carved into the surface of the wood.

The new finds from Tybrind demonstrate that only a limited number of the Ertebølle paddles were occasionally beautifully decorated with sophisticated patterns. This category of decorated paddles is unique within the European Mesolithic. In the latest survey of the portable art of Mesolithic Europe (Płonka 2003) no similar finds are recorded. If one has to look for related types of art – especially regarding the face-like design, cf. Figures 1.5, 1.7, and 1.8 – it is to be found in regions which geographically and chronologically lie far from the Danish Late Mesolithic Ertebølle Culture, for example among the Northwest Coast Indian tribes of North America (Boaz 1897: figs 3, 18, and 75) and in the Pacific (Buck 1950; Bodrogi 1959: figs 53, 70, and 76). However, ornamentation with curved bands, etc., is also known from the European Late Palaeolithic (Rust 1937: figs 43 and 45) and from the Iron Gates Stone Age (Radovanović 1996: figs 3.53 and 3.62).

Works of art are well known from the early Ertebølle (Andersen 1981: 46), but in these cases the art is exclusively of a strong geometric type. With regard to the motifs, rows of dots are well known from ornamented Ertebølle objects of bone, antler, amber, and ceramics (Andersen 1981), but in these cases they are seen as drilled or impressed dots. Similarly, bundles of thin, parallel lines constitute a common motif on many (mainly western Danish) Ertebølle artefacts (Andersen 1981: fig. 28, no. 3). In contrast, all the other motifs on the Tybrind paddles are new. The greatest difference is to be found in the curved designs, the ovals, the rhomboid figures, and the spectacle-like designs, as well as the bird's wings – these are all types of ornament that have not been found on objects of harder materials (Fig. 1.11).

The differences between the ornamented paddles and the other objects bearing Ertebølle art could either be explained as a function of differing age (early *versus* late Ertebølle art) or by the fact that here, for the first time, we have an art style executed in a soft material (wood). In the Mesolithic there were probably different types of art for hard materials (bone, antler, and amber), others for wood and a third/fourth for soft materials such as bark, clothing, leather, and the human body.

Function

The heart-shaped paddle type could suggest a use for paddling in shallow, protected waters, but modern experiments demonstrate that they are also suitable for paddling on more open, rougher

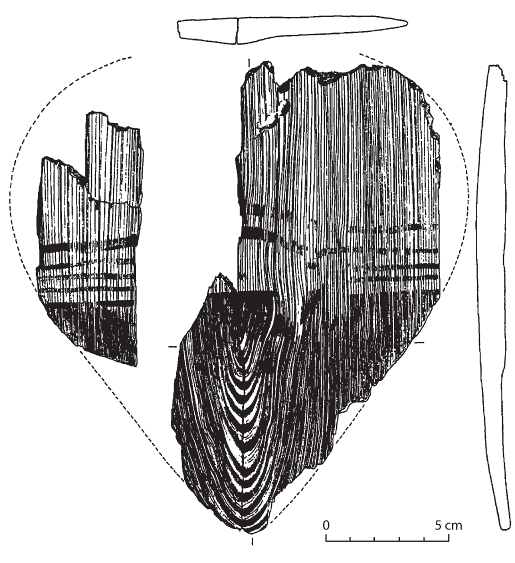


Figure 1.10: Paddle from the refuse layer in front of the Ertebølle kitchen midden at Flynderhage in Norsminde Fjord, east Jutland. The paddle has a painted decoration on one side only (Drawn by F. Bau)

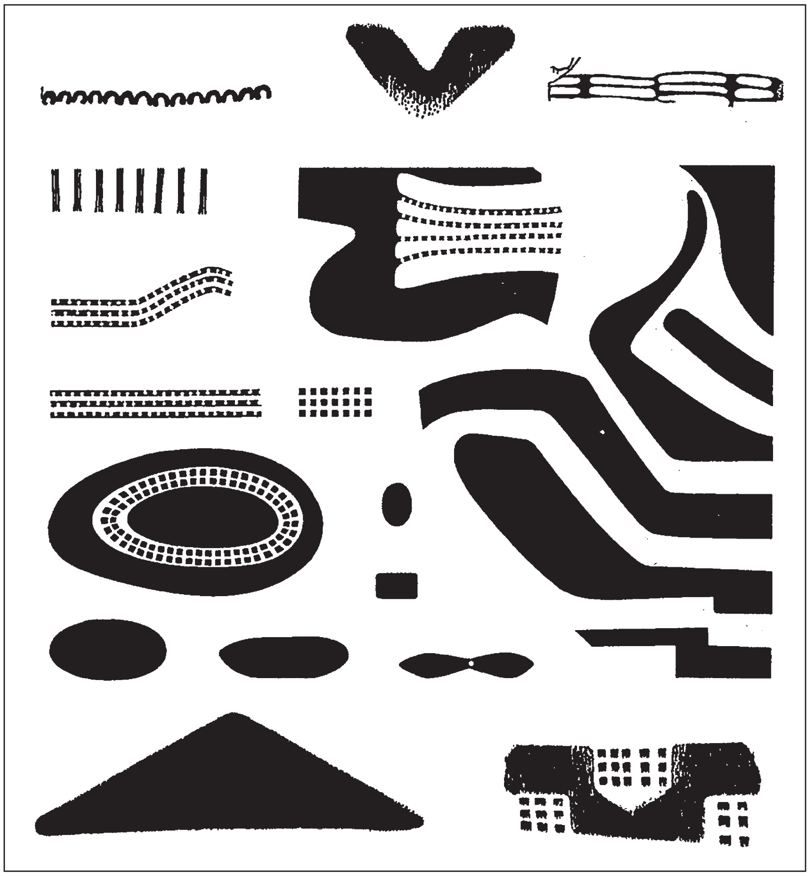


Figure 1.11: Reconstruction of the designs on the paddles shown in Figures 1.5, 1.7, and 1.8 (Drawings: Sven Kaae, E. Morville, and L. Hilmar)

waters (Christensen *et al.* 1973). Another possibility is that these paddles were used for boats with a particularly high freeboard similar to, for example, the *Umiaks* or women's boats of East Greenland. Here the shape of the oars is a reflection of the sex (and age) of the owner, and of its function. The fact that this type of paddle is known from both inland (Satrup) and coastal settlements (Tybrind Vig, Flynderhage, Teglgårds, Ronæs Skov, and Gamborg Fjord) shows that it was used both on inland lakes and at sea.

Traces of breakage, wear, and splitting of the paddle indicate use as ordinary/everyday implements, but one should not rule out use as ceremonial paddles or paddles with a particular status-related significance for their owner. The finely decorated surface would have been destroyed if used daily, and they could only have been used in special situations or on special occasions. These paddles were decorated for the purpose of visual signalling (Nash 1998: 67) indicating a totemistic society. The fact that it was paddles that were ornamented is understandable when one considers that these implements were used away from home and when entering neighbouring territorial waters. Therefore they were likely to have been of great significance as individual or group identifiers. If we follow this line of argument, it is obvious that one should also expect decoration on other types of objects used (and lost) in a similar way, such as canoes and arrows. However, in spite of close examination of the outer surfaces of the boats, such decoration has so far not been documented.

Dugout canoes

The position of the site, and the many traces of paddles and fishing activities, make it obvious that the inhabitants of Tybrind Vig must have navigated the shallow waters of the cove; it is therefore not surprising that one almost complete canoe (Tybrind I) and large portions of three or four others were found at Tybrind Vig (Andersen 1985: fig. 4). What the appearance of these Late Mesolithic dugout canoes has demonstrated for the first time is the outstanding wood technology used, the thinness of the vessels' hulls, how soft the wood was after 5000–6000 years in the seabed, and how this soft wood had become 'flattened' by the pressure of the overlying sediments. Finally, it was also shown how frequent finds of fragments of such boats were on these settlements and in the refuse layers adjacent to them. All these factors explain why we have only found Mesolithic boats by excavation during the last *c.* 20 years. These observations have been confirmed by later excavations of coastal settlements – both submerged, e.g. Ronæs Skov (Andersen 2009: 117–24, figs 100–1) and on dry land, e.g. Lystrup Enge (Andersen 1996: 7–38) and Halsskov (Pedersen *et al.* 1997).

The Tybrind I canoe

This boat is a surprisingly large vessel – an impressive example of the high level of woodworking technology in the Late Mesolithic. It is *c.* 10 m long and 0.50–0.65 m wide. The height of its side is *c.* 30 cm and the hull's thickness ranged between 2 cm and 3 cm; the centre line and the stern being the thickest parts, while the sides are 1–1.5 cm. The finding of such a long, thin-sided vessel on the seabed *c.* 200–300 m from the present day coastline raised several problems – primarily, how to excavate and salvage such a boat. Was it at all

possible to get it onto dry land? Nobody had tried anything like this before. First it was excavated/exposed *in situ* on the seabed. Then the canoe was cut into blocks each measuring 1 x 1 m, which were lifted separately, brought ashore, and reassembled there (Fig. 1.12). The vessel was then transported to the museum laboratory for final and careful excavation, drawing, and for study by wood specialists. The canoe was conserved by freeze-drying and is today on display at Moesgård Museum in Århus.

All the Tybrind canoes are made of long, straight trunks of lime (*Tilia* sp.). Oblique chopping marks and marks from splitting by wedges are visible all over the inner surface and indicate the use of flint or greenstone adzes. There were no signs that fire was ever used to hollow out the vessels. The tree used for the Tybrind I vessel was carefully selected, because only two traces of side-branches were observed along the whole length of the boat. The outline is lanceolate, with a pointed, slightly raised bow and cut-off, open stern. The cross-section is U-shaped. Later finds of Ertebølle boats, e.g. Lystrup Enge, show that the bark and small branches were also cut away as part of the construction process (Andersen 1996: 29, 38). The stern of boat I was open and (as seen in profile) obliquely truncated, meaning that the rail of the bulwark projected *c.* 3 cm further than the bottom and ended in a rounded tenon (Fig. 1.13). The sides are nicely rounded and terminate in a smoothly rounded gunwale, which is thicker than the side, probably in order to strengthen the vessel. No visible traces of the attachment of other structural features (no holes in the gunwale, extra side planks and/or outrigger) have been documented, although this does not rule out such a possibility. In the stern there were a series of regular, round depressions cut in the bottom and sides. The open stern suggests the boat must have been closed by a removable bulkhead. This, however, was not found. Inside the hull and *c.* 0.30 m from the stern, all the boats have a *c.* 60 x 35 cm and 1–5 cm thick, oval hearth made from a mixture of clay and sand (Fig. 1.12). This feature may be connected with eel fishing (flaring), but other explanations are also possible, such as the transport of fire from settlement to settlement (Fig. 1.14). Small patches of charring are also found at the bow – probably an indication of another fireplace in this part of the boat. Thus, the Tybrind I canoe had one or perhaps two hearths inside the vessel. This observation is supported by the fact that other finds of Ertebølle

Figure 1.12: The Tybrind I canoe on the shore after 6300 years in seabed sediments. Inside (on the bottom) of the canoe is a hearth of sand and clay. The hearth is partially covered by the port side, which has been pressed into the boat by the weight of the overlying sediments. In the centre of the vessel is a large stone, which was probably used as ballast or as a stabilizer (Photo: Søren H. Andersen)

Figure 1.13: The stern of the Tybrind I canoe with a series of eight depressions for the attachment of a bulkhead. The outline of the stern is concave (Photo: Søren H. Andersen)

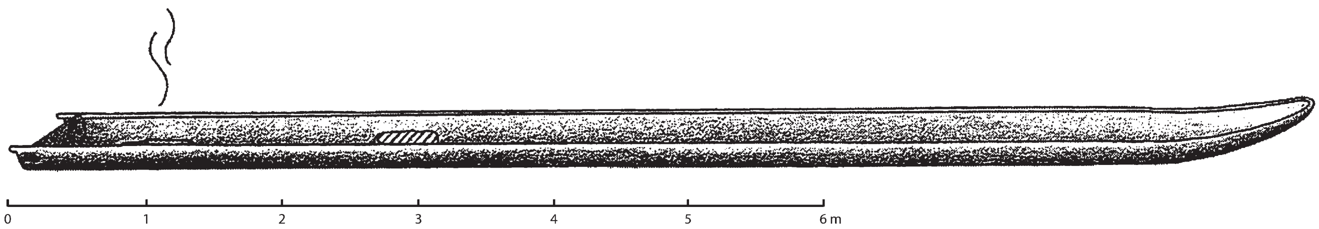


Figure 1.14: Reconstruction of the Tybrind I dugout canoe (Drawn by Orla Svendsen)

canoes also show a second fireplace in the bow, so some canoes had two hearths – one at each end. About 2.50 m from the stern, a large flat-sided stone (40 × 45 × 14 cm) weighing *c.* 30 kg was found. This may have served as a ballast stone to ensure controlled navigation with such a long slender boat. Another explanation is that the stone may have served as a weight to keep the boat underwater when it was not in use (to hinder drying out and splitting of the wood) and finally it may have functioned as a stabilizer.

In a terrestrial biotope covered by primeval forests and wetlands (swamps), water-based communication and transport along the coasts and inland (rivers and lakes) must have been the simplest (and easiest) way. Dugout canoes must therefore have been one of the most essential items for the Ertebølle population. These boats must have been of extreme importance because they combined both social (transport, communication, and travel from settlement to settlement) and subsistence activities (fishing and sea-mammal hunting). The use of boats widened the radius of economic activities greatly, expanded transport capacity, facilitated exchange of goods and information, and strengthened socio-economic collaboration, for example in hunting of migrating sea mammals (Andersen 2009: 183–91, fig. 173).

Transport capacity is a determining factor for the mobility of Stone Age groups. These boats were capable of carrying a considerable cargo, and modern estimates indicate a carrying capacity for the large Tybrind I boat of 6–8 persons with equipment (i.e. 500–600 kg) (Andersen 1987b: 99; E. Kannegaard, pers. comm.). Canoes of such impressive dimensions may have also had prestige value.

The tree used for the Tybrind I canoe was a thick, straight lime trunk of no less than 10 m length and 70–100 cm in diameter with an estimated weight of *c.* 3.5 tons. Considering the finished vessel weighed 250–350 kg, this means that some 93–94% of the original tree trunk had been hewn away (Andersen 1996: 35). Only in one case (the Agernæs site on northern Funen) are there definitive indications in the form of a thick layer of wooden chips that such canoes were hollowed out at the settlement (Jæger 1998: 12, 2000: 35). No doubt this operation was normally carried out at the place where the tree grew in the primeval forest.

Modern experiments show that it is possible for two skilled persons to make a similar dugout canoe in the course of one – or three to four weeks (Christensen 1990: 140; E. Kannegaard, pers. comm.). With such a large investment of labour required, it is understandable that much effort was expended in keeping these vessels functional for as long as possible. Lengthwise splitting seems to have been a general problem with such vessels, and traces of several repairs are found on the Tybrind II canoe; a hole in the bottom of the port side of the boat was covered (closed) by a patch of wood, bark, or leather and a lengthwise split had been repaired by drilling a series of small holes on either side of the crack in order to sew it together. Similar repairs have been documented on other dugout canoes, e.g. Lystrup Enge (Andersen 1996). Modern experiments have demonstrated that such a dugout canoe begins to rot and split lengthwise (just like the prehistoric examples) after being exposed to open weather for about 8 years (E. Kannegaard, pers. comm.).

Such long, thin-sided canoes must have been difficult to control and manoeuvre. Therefore, it is most reasonable to assume that they were generally used on sheltered, calm waters, but an experiment in 1979 demonstrated that it was possible to cross the Øresund between Zealand and Sweden (15 km) in *c.* 5 hours in a similar type of vessel paddled by two people (Christensen *et al.* 1979: 94).

From the ethnographic record, there are several depictions of the use of similar vessels. In these, people are always standing up in the boat using either paddles with long shafts or poles. In general, the ethnographic information stresses that poling is much more common than

paddling with such boats.

Conclusions

The Tybrind Vig settlement has demonstrated the significance and potential of finds from submerged settlements. The investigation of this settlement has advanced our knowledge of the Danish and European Stone Age in several ways. It has provided us with a wealth of new data on material culture, especially involving technologies relating to soft, organic materials. Also, for the first time, it has stressed the ubiquity of watercraft, their accompanying accessories, fishing equipment, and other tools made of organic raw materials at that time. For the most part, these have not been preserved at other settlements. Moreover, it has been demonstrated that it is technically feasible to perform underwater excavations of Mesolithic settlement sites in Danish waters.

Not only has Tybrind Vig expanded our knowledge of Mesolithic technology and material culture, the finds of ornamented paddles have also provided an insight into a hitherto unknown art form. Four of the paddles were decorated by ornamentation carved and/or stamped in shallow relief into the surface of the wood. The motifs are new and are characterized by a combination of geometric and non-geometric, more round and curved designs, in sharp contrast to what was previously known about Ertebølle art. There is also the spectacular discovery that three of the best-preserved ornaments show a strong similarity to human faces/masks. Additionally, the finds of large dugout canoes at Tybrind Vig are another spectacular aspect of this submerged settlement. The many fragments of canoes demonstrate how common such boats were and the *c*. 10 m long Tybrind I canoe illustrates the high level of woodworking technology in the Late Mesolithic. The fact that such canoes combined both social and economic aspects of society made them of extreme importance for the coastal population – they were probably the most important implement of all.

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2

The Excavation of a Mesolithic Double Burial from Tybrind Vig, Denmark

Otto Christian Uldum

The submerged settlement site in Tybrind Vig in Denmark was the subject of a decade-long investigation, which provided a wealth of new information about the material culture of the Late Mesolithic in southern Scandinavia. In 2004 a grave containing two adult individuals was discovered at Tybrind Vig. The present paper provides an account of the excavation of this inhumation burial. The carefully prepared Mesolithic burial contributes to the existing record in Denmark, which until now has consisted mainly of slightly younger examples.

Keywords: underwater archaeology, excavation, burial, Mesolithic, Tybrind Vig

Pioneering underwater investigations in Denmark

Much of the Danish sea territory was dry land during the Mesolithic. Until the availability of modern scuba diving equipment, most of these landscapes were out of reach of archaeologists. Amateur divers, interested in archaeology and co-operating with museum archaeologists, were the first to go under water with the specific purpose of finding remains of Stone Age settlements. The positive results of these initiatives inspired professional archaeologists to make use of scuba equipment in connection with Stone Age investigations. Archaeologists from the Langeland Museum were the first in Denmark to take such an initiative, when in 1972 they began the exploration of the submerged Late Mesolithic Møllegabet site (Grøn and Skaarup 2004).

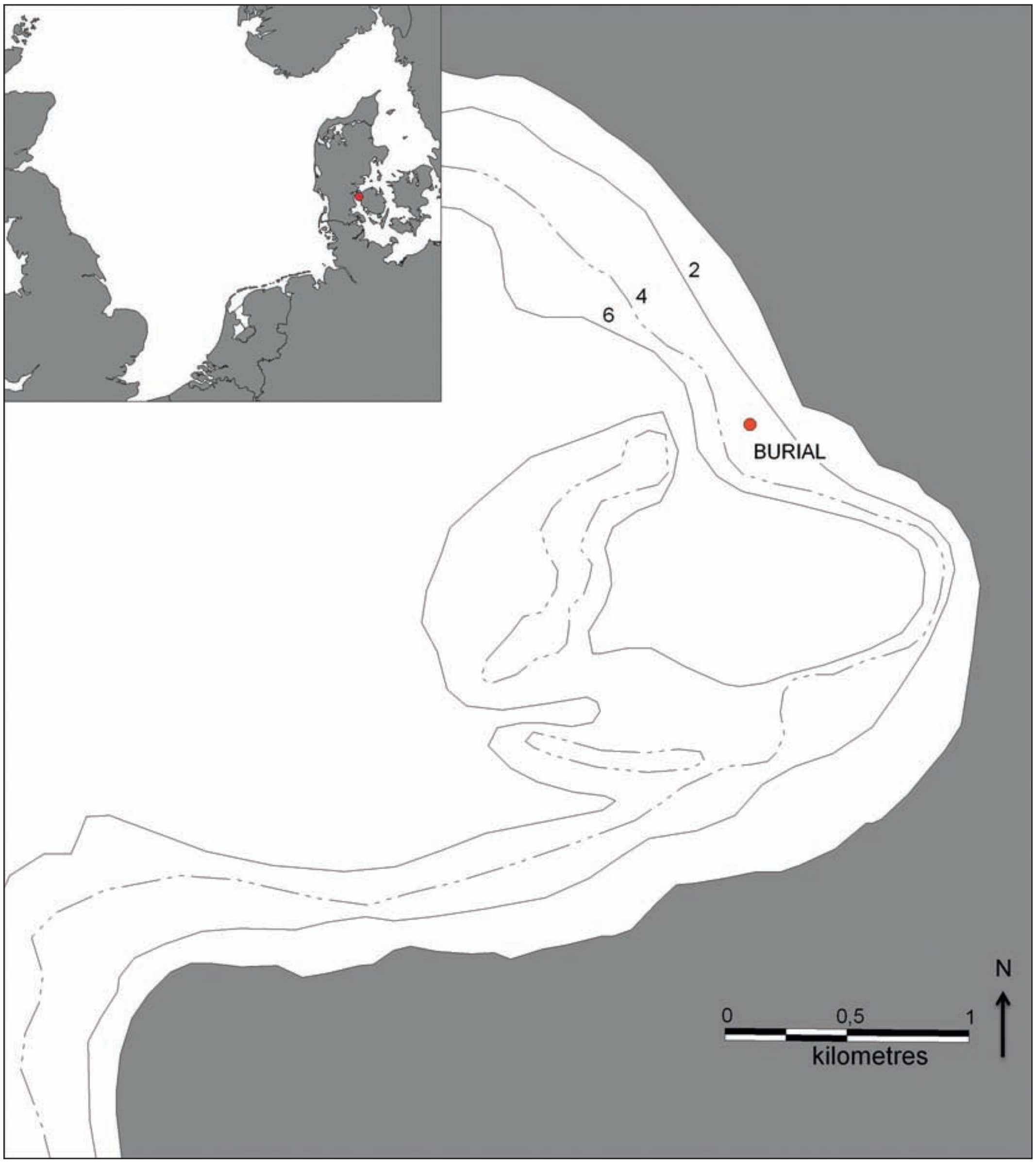
The next initiative for the investigation of a submerged settlement was taken by Moesgård Museum and Århus University at Tybrind Vig off the west coast of the island of Fyn (Funen) (Fig. 2.1). Between 1978 and 1987 this site was subject to annual archaeological investigations lasting several weeks. It was demonstrated that the cultural layers of the site spanned the entire Ertebølle Culture, 5400–3900 cal BC. Professional archaeologists led the project, but amateur divers carried out much of the fieldwork, including survey and systematic excavation.

During the ten-year excavation campaign at Tybrind Vig a wealth of new information was gathered, as the conditions for preservation of organic materials were very good. Wooden artefacts such as boats and paddles along with leister prongs reflected the intensive use of marine foods, as well as giving a completely new insight into ornamentation in the case of the inlaid paddles (Andersen 1985, 1987). Other, hitherto unknown, find categories included fragments of textile made from plant fibres. Artefacts of bone and antler were also very well preserved, as was the extensive lithic material.

Submerged burials

In 1979 an inhumation grave, containing the remains of a young woman and a child, was exposed due to erosion of the Tybrind Vig site. It was excavated, and later dated by radiocarbon to 6740±80 BP (K-3558, uncorrected for the marine reservoir effect) using a sample taken from the

Figure 2.1: The location and topography of Tybrind Vig. The 2 m, 4 m, and 6 m bathymetric curves are indicated. The area investigated during the 1970s and 1980s is located to the north and east of the burial



remains of the woman's femur (Andersen 1985; Fischer *et al*. 2007). This burial contained no grave goods or other signs of ritual, as has often been the case in the slightly younger (Ertebølle) Mesolithic graves from Denmark, e.g. Vedbæk (Albrethsen and Brinch Petersen 1976).

In 2004 another burial was discovered at Tybrind Vig, this time a little further out into the bay. The same group of amateur divers that formed the mainstay of the team from the ten-year-long Tybrind Vig project reported the find, and raised some skull fragments that were submitted to Moesgård Museum in Århus. Radiocarbon dates were obtained on samples from both individuals. The larger individual, probably male, gave a determination of 6820±55 BP (AAR-9341, uncorrected), from a sample of the mandible. The smaller individual, presumably female, was dated to 6905±55 BP (AAR-9342, uncorrected) using a sample taken from a rib. Fischer *et al*. (2007) discuss the $\delta^{13}C$ and $\delta^{15}N$ values associated with these dates and apply a marine reservoir correction to the ^{14}C ages.

The first attempt at excavating the burial (2007)

Since the end of the Tybrind Vig project in 1987, Danish waters have been divided into five areas, each under the auspices of a museum recognized by the Danish Heritage Agency.

Tybrind Vig is in the zone for which the Langeland Museum has responsibility. In 2007 the Danish Heritage Agency provided funding toward the documentation and excavation of the burial. The museum assembled a group of diving archaeologists from Langeland and Haderslev, and Trondheim in Norway, and settled in a nearby summerhouse. The historic vessel, *Mjølner*, owned by the Langeland Museum, served as a base, and this was supplemented by a 14-foot boat and a small inflatable. The team had two weeks to complete their work, and promptly went ahead by removing the protective covering of rocks and sandbags. Since 2004 seaweed had transformed the cover into a dark-green oasis in the sandy surroundings. The area around the burial was strewn with exposed flint artefacts, interspersed with pebbles. Immediately beside the burial, two fossil tree trunks from the transgressed Stone Age forest lay partly embedded in the sediment.

The burial lay some 250 m from the shore, at a depth of 3 m, in the outer part of the Tybrind Vig site (Fig. 2.1). The bay is almost semicircular, directly exposed to the west and the prevailing winds in Denmark. The bathymetry of the bay shows a prehistoric lagoon, with its entrance to the north, providing relatively deep water only 250 m from the present shore. The settlement area that was the object of the decade-long investigations lies near the entrance of the lagoon, on its landward (eastern) side, and the new burial is in the western, deepest part of this area.

The Norwegian contingent from the Science Museum in Trondheim, which like the Langeland Museum, has the responsibility for the underwater heritage management of a large area, initially went in the water to familiarize themselves with Danish shallow, sandy bottom – and with the abundance of worked flint that had been washed out of the sediment. It was a challenge for them not to raise large quantities of flake axes and fine blades, as per the instructions from the museum in charge. Given the limited amount of time available for the documentation of the burial, the cataloguing of stray finds was not a priority.

After the protective covering had been removed, and the rocks and sandbags placed to one side, a frame of scaffolding measuring 4 × 4 m was put into place on four vertical posts. Then levels were taken on the seabed within the square using a clear plastic tube mounted on a pole with a marked fix point. The top layer of loose sand was removed with a water dredge with a mesh bag tied to its ejecting end, thus collecting any rocks or artefacts contained in this layer. As these

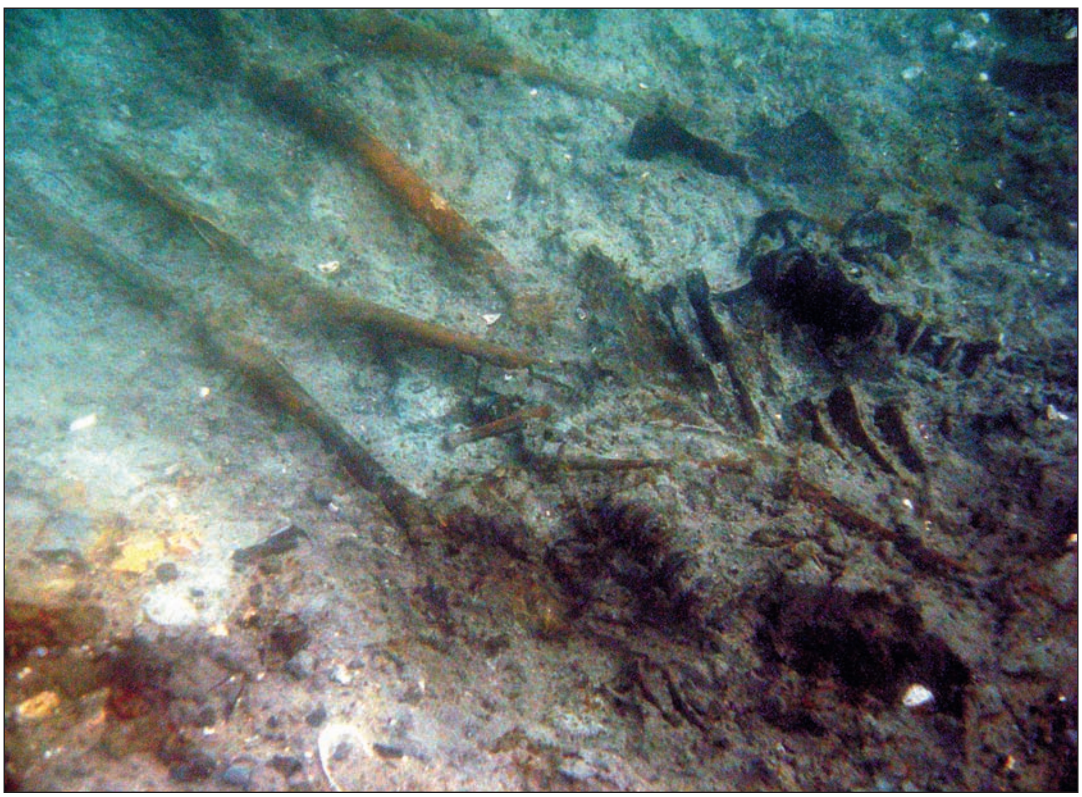


Figure 2.2: Diver's view of the burial immediately after it was uncovered

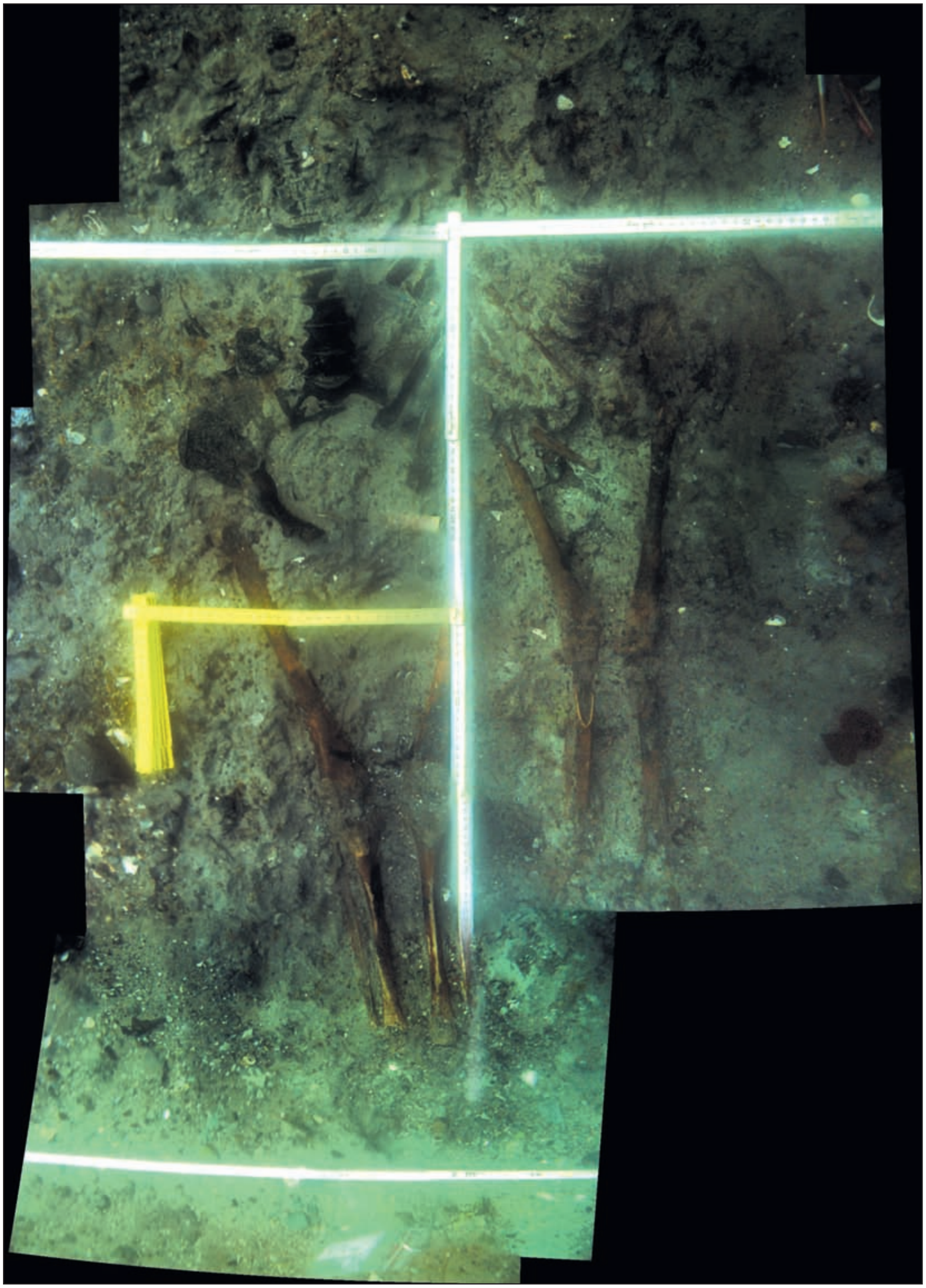


Figure 2.3: Photo mosaic of the double burial

were considered to be in a secondary position, their positions were only recorded to the nearest 2 × 2 m square. Under the loose sand was a fine clayey gyttja, through which roots of rushes had grown in such amounts that this deposit was initially mistaken for peat. This surface was also levelled. The burial then became visible as a depression and, at an arm's length from this, there was a semi-circular line of rocks, which was probably created in 2004 when the burial was discovered. Since 2004 the location of the skeletons had been marked by a piece of cloth,

and two pairs of stainless steel pins. When the cover was removed, 60 cm of perfectly preserved spine was visible. It could be seen that the person had been buried with the pelvis toward the east, and the head to the west.

By this stage the weather had deteriorated, and diving had only been possible during two full days, in addition to about two half-day's worth of work in strong winds and a choppy sea. It was not likely that the burial could be uncovered and documented in the amount of time available, and the decision was made to cover the burial once more, and hope for better conditions at another time.

The following season – uncovering and salvaging in 2008

A new team was assembled in 2008, when colleagues from Moesgård Museum in Århus joined the Langelanders in mid-June. The *Mjølner* was again used as a working platform, but the ship had to seek shelter in the nearest harbour at night, again due to rough weather. This time the team only had one week at its disposal, and hopes for better conditions than the previous year were high. In what amounts to two full working days, the most basic tasks were fulfilled, and with the bones properly packed, the team was able to leave Tybrind Vig.

The protective cover had fared well since 2007, and the sandbags were once more piled some distance away. A thin layer of sand had accumulated, but this was soon removed with the dredge. Uncovering of the grave began, and contact with the second individual was soon made. Previously, this burial had only been known from the find of a second skull in 2004. The sediment was firm enough to safely uncover the two skeletons in their entirety, without fear of having bones carried away by waves and currents. In the course of one long day, both skeletons were laid bare (Fig. 2.2), and the measuring could begin. The burial consisted of two individuals. The largest one, probably male, was lying toward the south, as previously mentioned, with the head oriented to the west. This was also the case with the somewhat smaller individual, probably female, lying to the north snugly against the larger individual. Both had been placed flat on their backs, with their arms together in the pelvic region. The smaller individual lay slightly higher than the larger one, and must have been put into the grave last. The two were buried elbow to elbow (Fig. 2.3).

Only very little of the shoulder region was preserved on both skeletons, as this was in a higher position in the grave. The feet had almost entirely disappeared, which may have happened shortly after burial, as these lay at the same depth as the leg bones, which were otherwise very well preserved. The knees of both individuals had also deteriorated, and the small individual's femur was damaged.

The bones were not studied during excavation; on the contrary, great care was taken not to contaminate them with the DNA of the excavators. As soon as they were uncovered enough to be raised, a gloved hand would bag them immediately on the seabed, and place them in a specially designed lifting basket. It is hoped that ancient DNA can be recovered from the bones. In addition, samples of the surrounding sediment were taken with the aim of extracting *sed*aDNA from the humans as well as from other organisms that might have been present at the site during the time of the burial.

No artefacts were found in or associated with the burial, and no grave pit could be seen around the skeletons. However, it should be mentioned that the investigation was terminated as soon as the last bone was safely out of the water. It was not possible to carry out a thorough examination for traces of a grave pit owing to lack of time, but the burial location was covered once more in order for this to be done at a later date.

Conclusions

Mesolithic burials are few, and even a single additional example can provide valuable additional information. When the radiocarbon dates of the two individuals are adjusted for the marine reservoir effect, the age of the newly discovered double burial is *c.* 6500 BP (5500 cal BC), which corresponds to the transition between the Kongemose and Ertebølle cultural periods. The first Tybrind Vig grave found in 1979 is of approximately the same age. It was situated near the burial presented here, and the two burials could thus be part of a cemetery. As the second burial did not reveal itself to the participants of the initial Tybrind Vig project (during the hundreds of dives made on or near the spot), it is possible that more burials will appear as a result of the slow erosion that is taking place on the site.

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3

Mesolithic Hunter-Fishers in a Changing World: a case study of submerged sites on the Jäckelberg, Wismar Bay, northeastern Germany

Harald Lübke, Ulrich Schmölcke and Franz Tauber

In the 7th and 6th millennia cal BC, the Mesolithic hunter-gatherer populations of the North European Plain were confronted by massive changes in their environment, not only by the increasing reforestation of the landscape but also by the rapid and global sea-level rise. This process led to the final flooding of the Baltic basin and to the origin of the present Baltic Sea. The investigation of the human response to this fundamental environmental change was the main task of the geoarchaeological work group of the interdisciplinary DFG Research Unit SINCOS from 2002 to 2005 and the DFG project cluster SINCOS-II from 2006 until 2009. Wismar Bay in western Mecklenburg-Vorpommern was one of the primary regions of investigation, and several Stone Age sites were located during the surveys. Research vessels used geo-scientific equipment, such as side-scan sonar, multibeam echo sounder, and remotely controlled underwater video camera, in 6.5–11 m deep water. The sites belong to different phases of the Late Mesolithic and Terminal Mesolithic between 6800 and 5000 cal BC. The best-preserved sites were investigated by underwater archaeological excavation. This chapter provides an overview of the geological, archaeological, and archaeozoological results of the investigations.

Keywords: Baltic Sea, Mesolithic, Kongemose, Ertebølle, faunal history, marine geophysics, sea-level change

Introduction

In 1998 an intensive programme of surveys on submerged Stone Age sites off the southwestern Baltic coast of Mecklenburg-Vorpommern was initiated by the State Authority for Archaeological Heritage Mecklenburg-Vorpommern (Lübke 2002, 2003, 2004). Specifically designed for the localization of sites deeper than 5 m below present sea-level, close cooperation with marine geologists from the Baltic Sea Research Institute Warnemünde (IOW) was necessary to obtain information about the morphology of the recent sea bottom and to reconstruct the submerged palaeolandscape prior to the flooding of the Littorina transgression. The joint scientific work soon led to the discovery of several new Stone Age sites on the Jäckelberg, a moraine ridge located about 3 km off Poel Island in the outer Wismar Bay (Lübke 2006). One result of this cooperative effort was the formation of the interdisciplinary DFG Research group SINCOS (www.sincos.org) from 2002 until 2005 (Harff *et al.* 2005, 2007; Harff and Lüth 2007), and their continuation as the DFG Project cluster SINCOS II from 2006 until 2009.

The Wismar Bay has been central to research aimed at a detailed reconstruction of the Littorina transgression in the southwestern Baltic Sea and its implications for the palaeoenvironment and development of human settlements over the past

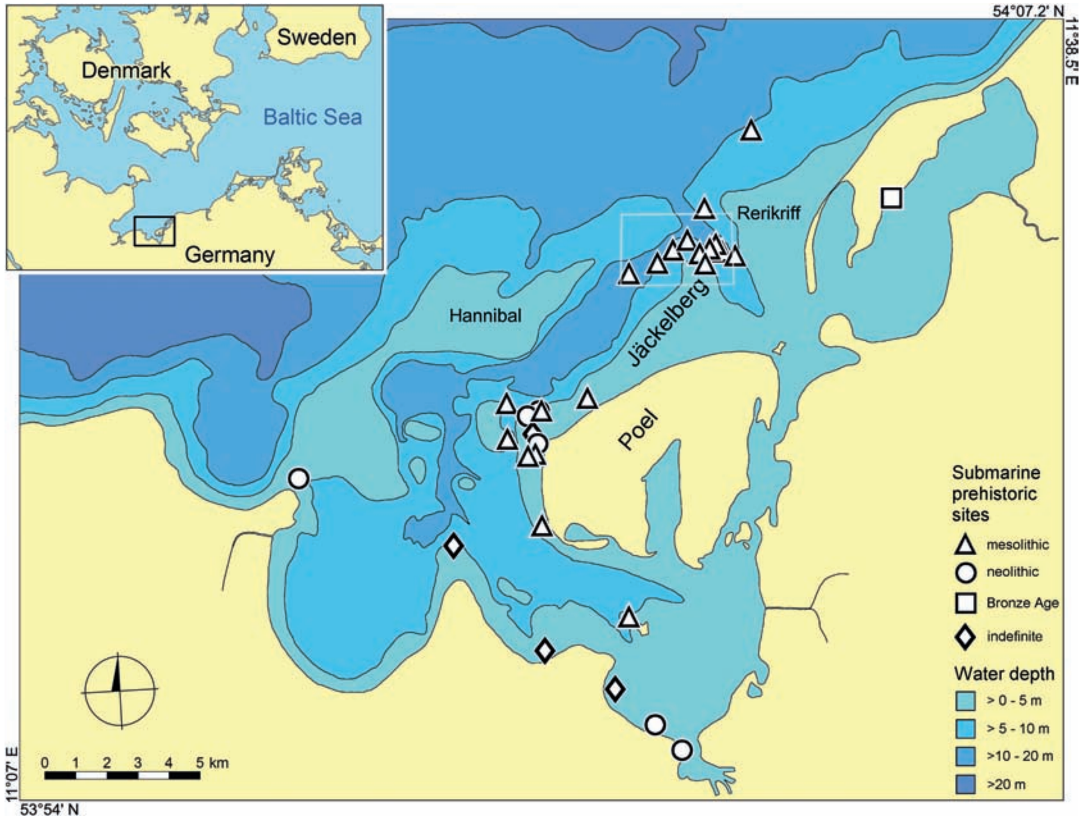


Figure 3.1: Wismar Bay, Mecklenburg-Vorpommern. Bathymetric map with submarine Stone Age sites found up until 2009. The Jäckelberg is a ground moraine ridge north of Poel Island. The area within the white rectangle is shown in Figure 3.2 (Digital drawing: H. Lübke and F. Tauber)

8000 years (Fig. 3.1). In the south, the shallow water of the Wismar Bay is surrounded by hilly moraine, while to the northwest the bay is separated from the open Baltic by shoals (Müller *et al.* 1997). Between these shoals and Poel Island, located in the southeastern part of the bay, a narrow channel has formed to the northeast with depths up to 15 m below present sea-level. Before the Littorina transgression, the area was a glacially-shaped valley with lime-oak forests and freshwater lakes. During the initial phases of the Littorina transgression, Wismar Bay first became a semi-enclosed fjord-like inlet, before it developed into the open bay that it is today. Its present sandy sea bottom is partly covered with peat layers, which mark the course of former shorelines, lakefronts, and riverbanks.

Marine archaeological geology

Side-scan-sonar surveys

From 1999 until 2009, ten expeditions with the research vessel *Professor Albrecht Penck* and one with *Ludwig Prandtl* took place in Wismar Bay. The main investigation area was the eastern part of the outer bay between the shallows of Hannibal, Rerikriff, and Jäckelberg, where the outlet of the former freshwater drainage system was situated, at the time when Wismar Bay was a semi-enclosed fjord-like inlet. For technical reasons, near-shore areas with a water depth of <6 m were not accessible for investigations with the *Professor Albrecht Penck*. During the first years of the project, maps of acoustic features were drawn manually from analogue sonar displays during expeditions to facilitate subsequent sampling on the seafloor. Raw sonar data were processed and georeferenced after the expeditions, and the resulting maps were used on later expeditions. Since 2003 navigation to sampling sites has continuously improved. Today, processing and post-processing of the raw sonar data begins aboard the research vessel immediately after recording. The actual geographical position of the research vessel can be displayed on georeferenced side-scan maps within just a few hours (Tauber 2007).

The side-scan surveys were performed with an EG&G DF-1000 dual-channel system (100 kHz and about 400 kHz). Using a slant range of 80 m, a swath of the seafloor with a width of about 150 m was mapped (for the principle of side-scan surveys, see Tauber 2007: fig. 1). The reflected intensities of the two acoustic

frequencies emitted and recorded by the side-scan sonar were used to create coloured side-scan images in a two-dimensional colour space instead of conventional greyscale or one-dimensional colour images. All side-scan images in colour have inverted brightness; that is, acoustically hard material appears dark while acoustic shadows are displayed as bright or white. Different types of sediments can thereby be distinguished more easily because the different ratios of reflectivity of both frequencies lead to a different colour hue and saturation (Tauber 1997). The horizontal precision of the Differential Global Positioning System (DGPS) receiver output was limited to 2 m, but a greater inaccuracy in the absolute geographical position of an echo source on the seafloor is caused by the changing position and angles of the sonar tow-fish relative to the ship. Therefore, a mean horizontal inaccuracy of about 20 m is assumed.

The quality of recorded sonar data changed from expedition to expedition. Weather conditions, rough seas, air bubbles and suspended matter in the water column, water currents, internal waves in the halocline or thermocline, and seasonal effects (i.e. varying abundances of seagrass, mussels, and fluff) can all have a strong influence on sonar images. Therefore, side-scan mosaics of different surveys may show different intensities, colours, and even textures in overlapping areas. The interpretation of side-scan images was improved successively through ground truthing – visual inspections with an underwater video camera or direct observations by scientific divers. In one instance relief edges consisting of eroded glacial till were initially interpreted as outcrops of organic sediment layers, but subsequent direct observations of the seafloor yielded the correct interpretation. In the course of time, sufficient expertise was acquired to distinguish between eroded till outcrops, sand dunes, fluff layers, and organic sediment outcrops due to slightly different acoustic reflectivity and the shapes of the features. Ultimately, it was possible to identify outcrops of organic sediment layers less than 10 cm thick.

Special attention was given to the detection of ancient shorelines, outcrops of organic deposits, and areas with suspected tree remains as well as prospective areas of Mesolithic settlements on evidence of the seafloor relief. Sites with outcropping organic sediment layers (peat and freshwater gyttja) were investigated in detail. Areas, such as the mud-filled deeper parts of the Mecklenburg Bay, where archaeological investigation seems to be impossible, were excluded from the surveys. The sonar data from the side-scan surveys of the Jäckelberg and its surroundings were compiled to a side-scan sonar mosaic of the investigated area (Fig. 3.2). In combination with a detailed bathymetric map this allowed for a reconstruction of the palaeolandscape with lake basins, river valleys, creek outlets, and an island ('Jäckelgrund')

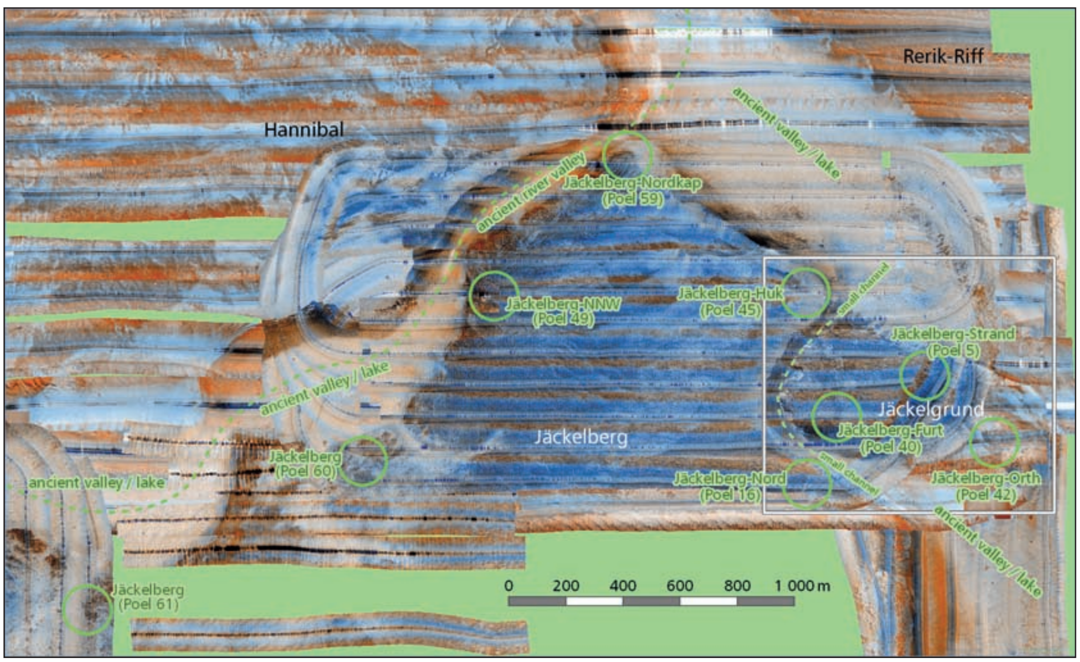


Figure 3.2: Side-scan sonar mosaic of the submarine landscape around Jäckelberg. Different colours represent the different acoustic responses of the seafloor. The bathymetry of the area within the white rectangle is shown in Figure 3.7 (Digital drawing: F. Tauber)

separated from the peninsula 'Jäckelberg' by a small channel. This reconstruction was an important basis for the discovery of numerous organic sediment outcrops, partially with *in situ* tree trunks and tree stumps, which were sampled for further geological, dendrochronological, and dendroclimatological studies (Lampe *et al.* 2005, 2007; Haeseler *et al.* 2007) and for further archaeological exploration of submerged Stone Age settlements.

Video observations

The review of the side-scan anomalies interpreted as outcrops of organic deposits or tree remains was carried out at first with different underwater video camera systems. In the beginning, a sledge system was used, which was pulled slowly over the seafloor by the research vessel drifting in the wind or current. But owing to the different and changing weather conditions it was not always easy to sail on course and it was not possible to stop the sledge when a point of potential interest was passed. Therefore, in later expeditions, the sledge system was replaced by a ROV. In this way it was possible to anchor the ship on site and to investigate any suspicious anomalies with ample time. The Hydrovision Hyball ROV system was used in most expeditions. The underwater section is connected to the surface control unit on board by an umbilical, which provides the telemetry, power and video link between the two units. The internal mounted camera with a rotation angle of 360° and with switchable spotlight as well as the excellent manoeuvrability of the underwater section, which can turn on its own axis, allowed optimum observation of conspicuous structures on the seafloor. In cases when the Hyball system was not available, a smaller Video Ray Scout system was used; but owing to the smaller power unit and the fixed, immovable camera of the ROV, the resulting monitoring was less productive compared to the Hyball system.

Geoarchaeological sampling

Once the side-scan survey diagnosis was confirmed by video observation, further investigation was conducted by an interdisciplinary team of scientific divers. In principle, the diving operations were carried out with a dive supervisor and a standby diver for emergencies according to the German rules for scientific diving.[1] The divers used SCUBA equipment with full-face masks and wireless voice communication transmitters.

Their first task was to verify the observations from the side-scan sonar or ROV images, in order to determine the composition and sedimentological origin of any organic sediments as well as to document the observed features with video and/or still cameras. It was particularly important to observe whether preserved tree trunks or stumps were present. In such cases, samples were taken for further dendrochronological and radiocarbon dating (Lampe *et al.* 2005, 2007; Haeseler *et al.* 2007). Sampling could be conducted by scientific divers with hand saws when the observed trunks were not too big or too resistant (hard) for this simple technique. In other cases, complete trunks were raised with the research vessel's crane in order to cut slices of the tree with a chainsaw kept on board.

The second task, particularly for the archaeological divers, was to survey the seafloor for the remains of any preserved Stone Age settlements. These were usually indicated by the presence of flint artefacts, and sometimes also bone or antler pieces on the seafloor. In such cases it was important to search for intact archaeological layers with bone, antler, or wooden objects in the adjacent organic sediments. Almost all of the submerged Stone Age sites presently known in the outer Wismar Bay were identified by these expeditions. Most of the newly discovered sites are situated at a depth of 6–12 m below present sea-level on the northeastern spit of the Jäckelberg moraine ridge.

Archaeology

The most promising sites were later investigated by the archaeological specialists of the team, using their own equipment. Three small boats were used: an 8.5 m long rigid-hull cabin boat served as a working platform for the four to five-member dive group, an open rigid-hull work boat of 5.5 m length was used to carry the required (fire) pump (with a working pressure of eight bar) for the underwater dredge and a 6.5 m rigid inflatable boat with outboard engine (for additional transport and protection of the divers). In general, two water (or induction) dredges were used in simultaneous operation. The trenches were excavated in single square-metre units and in spits of 4–10 cm, depending on the quantity of finds. The sediment from each excavation unit was captured with mesh bags (*c.* 3 mm mesh size), which were installed at the end of the dredges. The samples were

dried later at the dive base located at the harbour. Therefore, it was possible also to sort out small finds such as lithic arrowheads or fish bones. The underwater archaeological excavation techniques applied enabled appropriate detailed stratigraphical analyses of the investigated sites. Carefully documented sections supplied further information used in reconstructing the coastal morphology of the settlement environment. Extensive sample material was acquired from the excavated trenches for further environmental and archaeological analysis.

Figure 3.3: Jäckelberg-NNW. Big oak tree stump on the creek bank (Photo: H. Lübke)

Figure 3.4: Jäckelberg-NNW. Sunken hearth with charcoal, charred wood, and fire-cracked stones (Photo: H. Lübke)

Stone Age sites of the 7th millennium cal BC

The newly discovered sites in the outer Wismar Bay belong to different phases of the Late Mesolithic and early Terminal Mesolithic between 6800 and 5000 cal BC – a period which has remained rather obscure in northern Germany owing to the lack of stratified sites with preserved organic material (Hartz and Lübke 2006; Hartz 2009). The deepest sites to date were found in water up to 12 m deep at the northwestern edge of the former Jäckelberg peninsula. The sites were located at freshwater lakefronts or riverbanks of the main channel of the former valley and date back to the time before the Littorina transgression (cf. Roeßler 2006; Roeßler *et al.* 2007).

Because of the close proximity to the main navigational route to Wismar harbour, the responsible maritime authorities permitted only limited dive missions. Therefore little is known about the sites Poel/Neuburg 59, 60 and 61, Ostsee II,[2] except for a few flint artefacts with associated preserved organic sediments. However, the depth of the sites, at >10 m below present sea-level, suggests that they date to the 7th millennium cal BC. More intensive investigation of these sites is desirable as they are under threat by a planned expansion (broadening and deepening) of the navigational channel approach to Wismar harbour (scheduled within the next three years).

Jäckelberg-NNW

The excellent conditions (and depth) for the preservation of Stone Age sites in this area have been demonstrated by the site of Jäckelberg-NNW (Poel/Neuburg 49, Ostsee II). This site was found 11 m deep at the bank of a small creek's outlet into the main river valley. The banks of the creek bed are still partly covered with gyttja and mud sediments (Tauber 2007: fig. 5). In the transitional zone to the terrestrial area, several pieces of charred wood were preserved and, in what appears to be the former settlement area, some oak tree stumps (Fig. 3.3) and a sunken hearth with charcoal and fire-cracked stones (Fig. 3.4) were observed by divers during the last ship expedition in the spring of 2009.

In the immediate vicinity of the hearth and in the creek bed, several flint artefacts and a red deer bone were collected from the seafloor. One small trapeze, a microburin, several blade burins, and microblades in combination with a few other blade and flake tools indicate an early Late Mesolithic age for this assemblage (Fig. 3.5). The assumed time-range is confirmed by two radiocarbon dates from one of the tree stumps and the red deer bone. While the stump is dated to *c.* 6300 cal BC, the red deer bone has a slightly older age between 6600 and

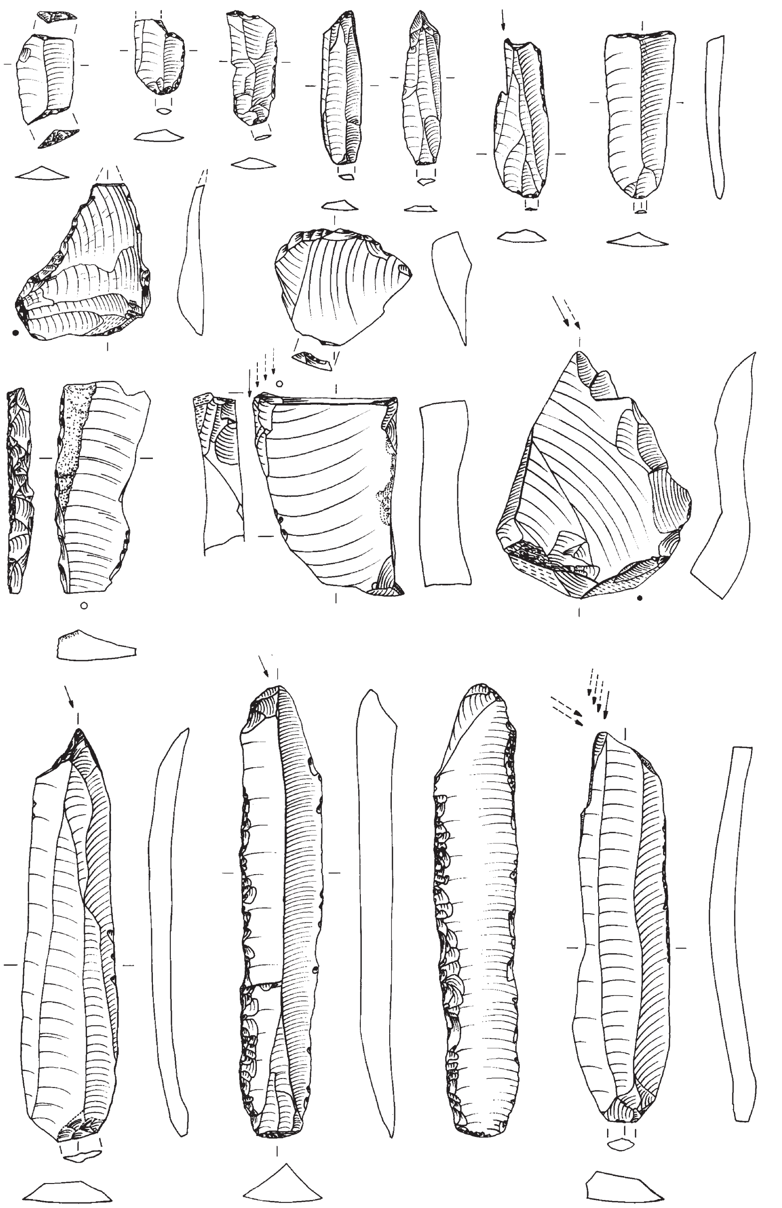


Figure 3.5: Jäckelberg-NNW. Flint artefacts. 1 trapeze; 2 microburin; 3, 7 truncated blades; 4–5 microblades; 6, 13–15 blade burins; 8 flake borer; 9 flake scraper; 10 backed blade fragment; 11–12 flake burins (Drawings: J. Freigang; Scale 1:2

6500 cal BC (Table 3.1). This suggests the site belongs to the transition from the Middle to the Late Mesolithic. Stratified sites with preserved organic remains from this period are unknown in northern Germany thus far. The need for further investigations at the southern edge of the main channel of the outer Wismar Bay can therefore be considered urgent.

Jäckelberg-Huk

Only slightly younger than Jäckelberg-NNW is Jäckelberg-Huk (Poel/Neuburg 45, Ostsee II). This site is situated on the northeastern edge of the Jäckelberg spit, at a depth of 8.5 m below sea-level. Here, excavations were undertaken in 2004 and 2005 (Jöns *et al.* 2007; Lübke 2009). The main cultural layer was found in the strongly humic upper horizon of the mineralized palaeosol, below a sequence of peat, mud, and sandy sediments. Two hearths exposed by the excavation showed that part of the actual settlement area, containing cultural layers, had been well preserved by the overlying peat (Lübke 2009: fig. 83.2). Several radiocarbon analyses date the main culture layer to between 6400 and 6000 cal BC (Table 3.1).

During the time of settlement, the site was situated in the immediate proximity of a freshwater lake, which extended (an unknown distance) into the area that is now Wismar Bay. The ancient lakefront near the settlement area was not located, although the main cultural layer was found at the base of the deepest test trenches, again in the mineralized palaeosol. The prehistoric lakefront is thought to be at least 10 m below present sea-level, which would correspond with the depth of Jäckelberg-NNW.

The sediments overlying the mineralized palaeosol consist of a succession of mud and reed peat layers, indicating varying but steadily rising water levels. Marine molluscs, a clear signal of the inundation of Wismar Bay due to the rising sea-level, were only observed in the higher sediment layers of the shoreline. Some mammal bone finds were recovered, though dating these sediments produced ages between 6000 and 5800 cal BC, which suggests they probably originated from a separate unknown site nearby.

The archaeological finds consist of a large number of flint artefacts and several bone implements. The lithic tool industry is characterized by broad trapeze-shaped, oblique transverse, or rhomboid arrowheads, and a few very small, elongated triangular microliths. Of the blade implements, numerous burins made from soft-hammered blades are the predominant artefact type. Furthermore, a small number of blade scrapers and straight or oblique truncated blades are present. Adzes are represented by a 'flake-adze-like' core adze and a few rejuvenation flakes from core adzes with a pointed-oval cross-section. Further diagnostic artefacts like macroblades produced by soft hammer technique, microblades, and the corresponding specialized microblade handle cores complete the inventory (Fig. 3.6).

The overall inventory is comparable to the few sites dated to the early phase of the Late Mesolithic in southern Scandinavia and northern

Sample description	Origin Trench, square unit, layer water depth	Sample material	Lab. No.	^{14}C Age (BP)	Calendar Age (cal BC/AD)	Calendar Age (cal BP) [0=AD1950]	$\delta^{13}C$ ‰†
Poel 49	Jäckelberg-NNW						
2002/1879-0037	Surface creek bed	Red deer	KIA-26392	7744±37	6570±50	8520±50	-23.0
2002/1879-0038	Surface seafloor	Oak tree stump	KIA-26400	7464±40	6330±60	8280±60	-26.0
Poel 45	Jäckelberg-Huk						
2002/1526-0035,1	Trench 1, N100/E103/-	Red deer	KIA-23699	7416±43	6310±60	8260±60	-22.5
2002/1526-0035,2	Trench 1, N100/E103/-	Roe deer	KIA-23700	7469±39	6340±60	8290±60	-20.5
2002/1526-0035,2	Trench 1, N100/E103/-	Pike	KIA-23701	7387±42	6290±60	8240±60	-15.5
2002/1526-0045,1	Trench 2, N100/E109/-	Mammal, indet.	KIA-23940	7239±37	6120±60	8070±60	-20.7
2002/1526-0053,1	Trench 3, N100/E115/-	Pike	KIA-23941	7108±37	5980±40	7930±40	-18.1
2002/1526-0818,1	Trench 5, N100/E114/A5	Pike	KIA-26393	7505±50	6360±70	8310±70	-24.1
2002/1526-0602,1	Trench 5, N100/E114/A5	Mammal, indet.	KIA-26394	7738±41	6570±50	8520±50	-21.7
2002/1526-0656,1	Trench 5, N100/E112/A6	Wild boar	KIA-26396	7446±32	6320±50	8270±50	-22.4
2002/1526-0656,2	Trench 5, N100/E114/A1	Red deer	KIA-26397	7179±35	6040±30	7990±30	-21.3
2002/1526-0817,1	Trench 5, N100/E114/A1	Seal	KIA-26398	7140±30	6020±30	7970±30	-15.4
2002/1526-0109,1	Trench 4, N100/E107/A2	Hazelnut shell	KIA-26403	7238±35	6120±60	8070±60	-25.3
2002/1526-0277,1	Trench 4, N100/E107/A4	Hazelnut shell	KIA-26404	7210±32	6070±40	8020±40	-25.3
2002/1526-0398,1	Trench 5, N100/E114/A1	Hazelnut shell	KIA-26405	6989±34	5890±60	7840±60	-22.3
2002/1526-0601,1	Trench 5, N100/E114/A5	Hazelnut shell	KIA-26406	7806±33	6640±30	8590±30	-27.3
2002/1526-0826,1	Trench 5, N100/E114/A7	Charcoal	KIA-26409	7309±41	6160±50	8110±50	-25.9
2002/1526-0873,1	Trench 7, N100/E126/A5	Mammal, indet.	KIA-31532	7063±42	5950±40	7900±40	-16.3
2002/1526-0906,1	Trench 7, N100/E126/A7	Seal	KIA-31533	7212±34	6080±50	8030±50	-17.6
2002/1526-0953,1	Trench 7, N100/E126/A12	Mammal, indet.	KIA-31534	7172±36	6040±30	7990±30	-20.3
2002/1526-0961,1	Trench 8, N100/E133/A1	Mammal, indet.	KIA-31535	7369±37	6260±70	8210±70	-19.5
2002/1526-1005,1	Trench 8, N100/E133/A7	Roe deer	KIA-31536	7030±39	5930±50	7880±50	-21.3
Poel/Neuburg 40	Jäckelgrund-Furt						
2001/2112-0004	Surface seafloor, 7.90 m	Oak tree stump	KIA-19323	7022±33	5930±50	7880±50	-25.2
Poel/Neuburg 42	Jäckelgrund-Ort						
2002/0977-0005	Surface seafloor, 7.20 m	Oak tree stump	KIA-18209	6969±33	5850±50	7800±50	-24.4
2002/0977-0025	Surface seafloor, 6.50 m	Oak tree stump	KIA-19240	7022±44	5920±60	7870±60	-24.1
2002/0977-0026	Surface seafloor, 6.70 m	Oak tree stump	KIA-19241	7014±36	5920±50	7870±50	-22.9
2002/0977-0027	Surface seafloor, 6.60 m	Oak tree stump	KIA-19242	6888±35	5780±40	7730±40	-21.5
2002/0977-0028	Surface seafloor, 7.20 m	Oak tree stump	KIA-19243	6916±35	5800±50	7750±50	-24.3
2002/0977-0031	SW peat edge 8.20 m	Oak tree stump	KIA-22803	7154±41	6030±30	7980±30	-26.5
2002/0977-0032	SW peat edge 8.50 m	Oak tree stump	KIA-22804	7090±32	5970±40	7920±40	-27.1
Poel/Neuburg 5	Jäckelgrund-Strand						
2001/2114-0008	Surface seafloor, 7.80 m	Oak tree stump	KIA-18210	6882±33	5770±40	7720±40	-28.0
Poel/Neuburg 16	Jäckelberg-Nord						
2000/0308-0012	Surface peat outcrop, 6.60 m	Wooden post	KIA-10401	6201±41	5150±70	7100±70	-27.1
2000/0308-0011	Surface peat outcrop, 6.50 m	Wild boar	KIA-10402	6326±36	5300±50	7250±50	-20.0
2000/0308-0037	Surface peat outcrop, 6.70 m	Red deer	KIA-11616	6253±39	5230±60	7180±60	-22.6
2000/0308-0038	Surface peat outcrop, 6.60 m	Wooden post	KIA-11617	6353±46	5350±60	7300±60	-27.5
2000/0308-0052	Edge peat outcrop, 7.20 m	Wooden axe haft	KIA-16024	6494±33	5450±50	7400±50	-27.7
2000/0308-0066	Surface peat outcrop, 6.70 m	Wild boar	KIA-16025	6673±28	5600±30	7550±30	-21.3
2000/0308-0083	Surface peat outcrop, 6.80 m	Wild boar	KIA-16026	6377±30	5380±50	7330±50	-16.8
2000/0308-0090	Surface peat outcrop, 6.80 m	Mammal, indet.	KIA-16027	6620±34	5570±40	7520±40	-20.4
2000/0308-0162	Surface seafloor, 6.80 m	Oak tree trunk	KIA 24221	6867±35	5760±40	7710±40	-26.5
2000/0308-0163	Surface seafloor, 6.70 m	Oak tree trunk	KIA-26401	6809±35	5700±30	7650±30	-25.4
2000/0308-0165	Surface seafloor, 6.70 m	Oak tree trunk	KIA-26402	6806±34	5700±30	7650±30	-22.4

† Comment from the Leibniz Labor für Altersbestimmung und Isotopenforschung, Christian-Albrechts-Universität Kiel: Please note that these $\delta^{13}C$ values include the effects of fractionation during graphitization and in the AMS-system and, therefore, cannot be compared with $\delta^{13}C$ values obtained per mass spectrometer on CO_2.

Table 3.1: Radiocarbon dates for the Stone Age sites on the Jäckelberg. The calibration was performed with the program CalPal, ver. 2007 (Weninger et al. *2009) and the calibration curve IntCal04 (Reimer* et al. *2004)*

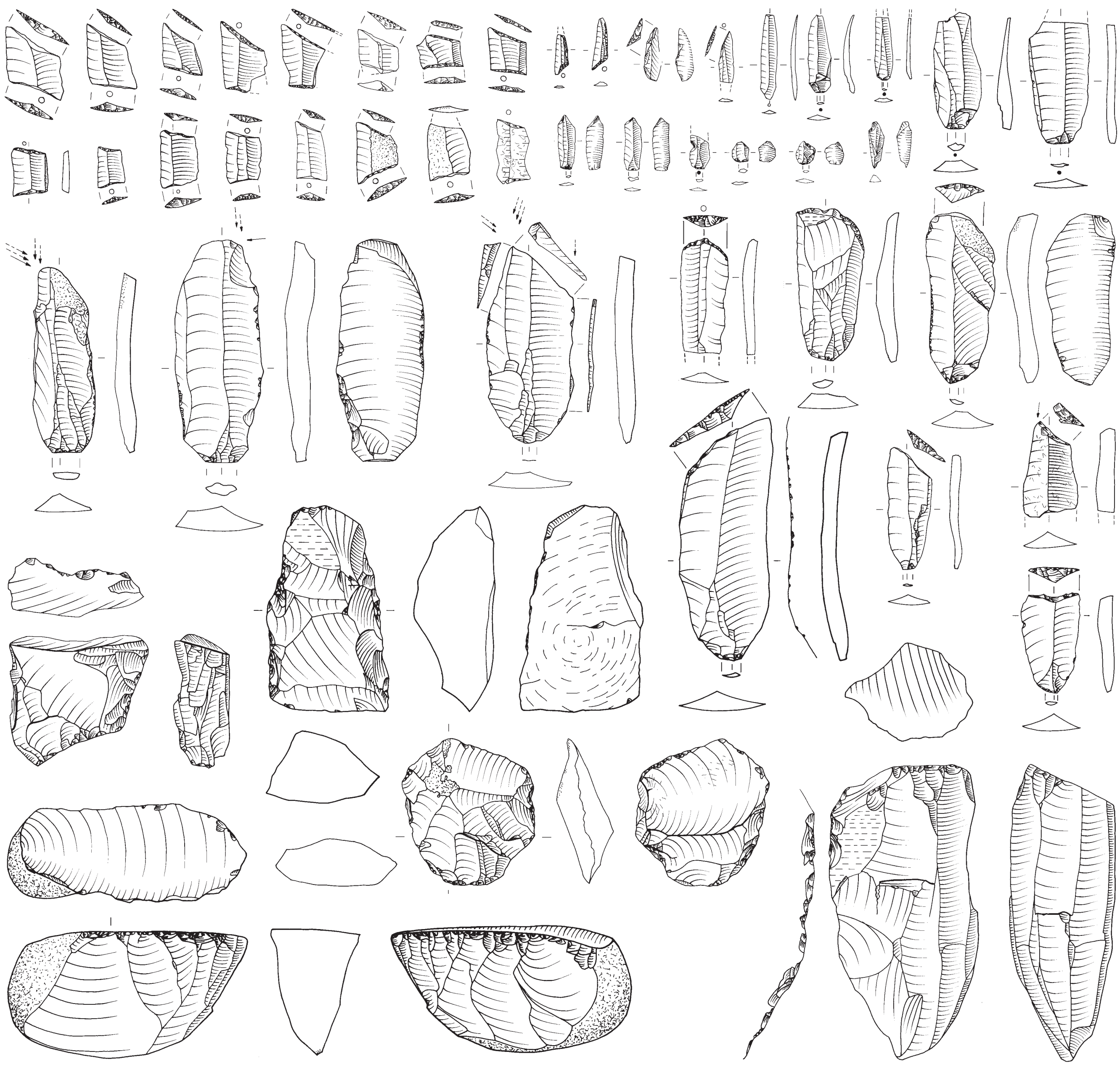


Figure 3.6: Jäckelberg-Huk. Flint artefacts. 1–5 rhombic arrowheads; 6–8 oblique transverse arrowheads; 9–10 triangles; 11–12 micropoints; 13–15 microblades; 10–23 trapeze; 24–29 microburins; 30–31 blades; 32–34, 39 blade burins; 35–37 blade scrapers; 38, 42 oblique truncated blades; 40, 45 microblade cores; 41 core adze; 43 straight truncated blade; 44 core adze rejuvenation flake; 46 blade core (Drawings: J. Freigang; Scale 1:2)

Germany such as Seedorf-Steinhorst (Seedorf LA 296) in Schleswig-Holstein (Bokelmann 1999), Ringsjöholm in Scania (Sjöström 1997), and in Denmark Musholm Bay (Fischer 1995; Fischer and Malm 1997) and especially Blak II, the eponymous site of the first phase of the Kongemose Culture, dated to 6400–6000 cal BC (Sørensen 1996).

Stone Age sites of the 6th millennium cal BC

Jäckelgrund-Orth

The geophysical investigations led to the identification of a small moraine ridge – the so-called Jäckelgrund – which rises to 6 m below present sea-level and is separated from the main moraine Jäckelberg ridge by a narrow channel that is up to 2.5 m deep and with a maximum

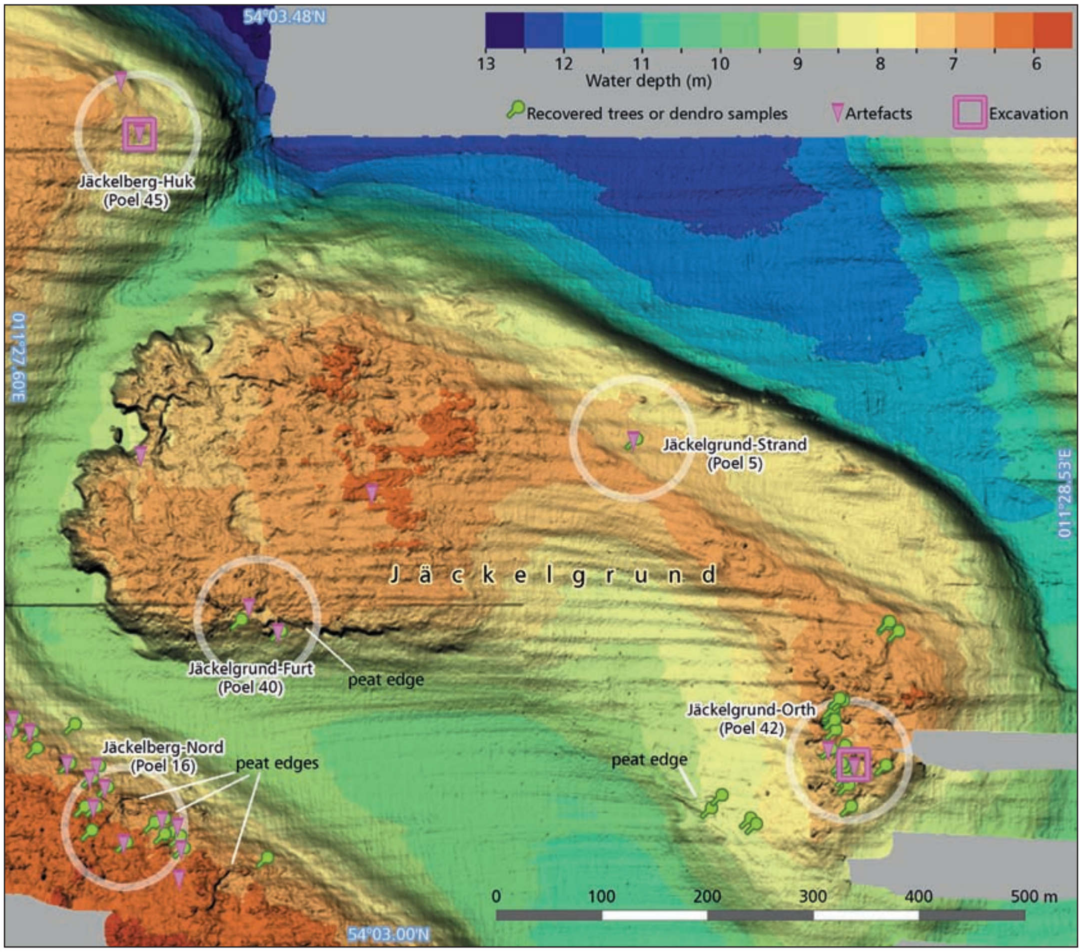


Figure 3.7: Relief map of the Jäckelgrund. Symbols show finds of artefacts, trees and tree stumps. Apparent furrows in east–west direction are hydrosweep artefacts. Finds were made and are shown here only in places that were investigated by scientific divers on the seafloor. Therefore, more places in the area of the map with artefacts and trees may exist, which are still undiscovered (Digital drawing: F. Tauber)

depth of 9.5 m below present sea-level (Fig. 3.7). Several radiocarbon-dated tree stumps found *in situ* at water depths of up to 8 m show that during the 6th millennium cal BC the Jäckelgrund must have been a small island on the edge of the *Großes Tief* (Great Deep) just off the Jäckelberg peninsula (Lübke 2004; Tauber 2007).

On this former island, three sites situated 7–8 m below sea-level were discovered through underwater surveys during the expeditions. The site of Jäckelberg-Furt (Poel/Neuburg 40, Ostsee II) is located to the west of the island at approximately 7.5 m water depth, at the southern entrance of the channel that separates the Jäckelgrund from the Jäckelberg. The second site, Jäckelgrund-Strand (Poel/Neuburg 5, Ostsee II) on the opposite, northeastern side of the island, is located in a water depth of *c.* 7–8 m on an ancient beach ridge beyond which the seafloor of the Great Deep drops to more than 10 m. Except for the remnants of tree stumps, no organic layers or objects have been discovered here to date.

The best preservation conditions were observed at the third site, Jäckelgrund-Orth (Poel/Neuburg 42, Ostsee II), on the southeastern tip of the island. There, again, several tree stumps were found in their original positions and, in addition to sharp-edged flint artefacts, a number of surface finds of animal bones and antler pieces were collected. Radiocarbon samples taken from the tree stumps produced dates between 5900 and 5700 cal BC, suggesting a similar age for the archaeological finds, which have yet to be dated by stratigraphical and/or radiocarbon analysis. A second peat edge was recorded approximately 150 m southwest of the main site at 8.2–8.5 m depth. Two oak tree stumps were dated to *c.* 6000 cal BC (cf. Table 3.1).

In 2008, some test trenches were excavated to verify the origin of the surface finds and to investigate the site's stratigraphy. The fossilized topsoil had been preserved within an area up to 5 m wide under a thin surface gravel layer. To the south and east it descends and is overlain by a sequence of peat and sandy mud

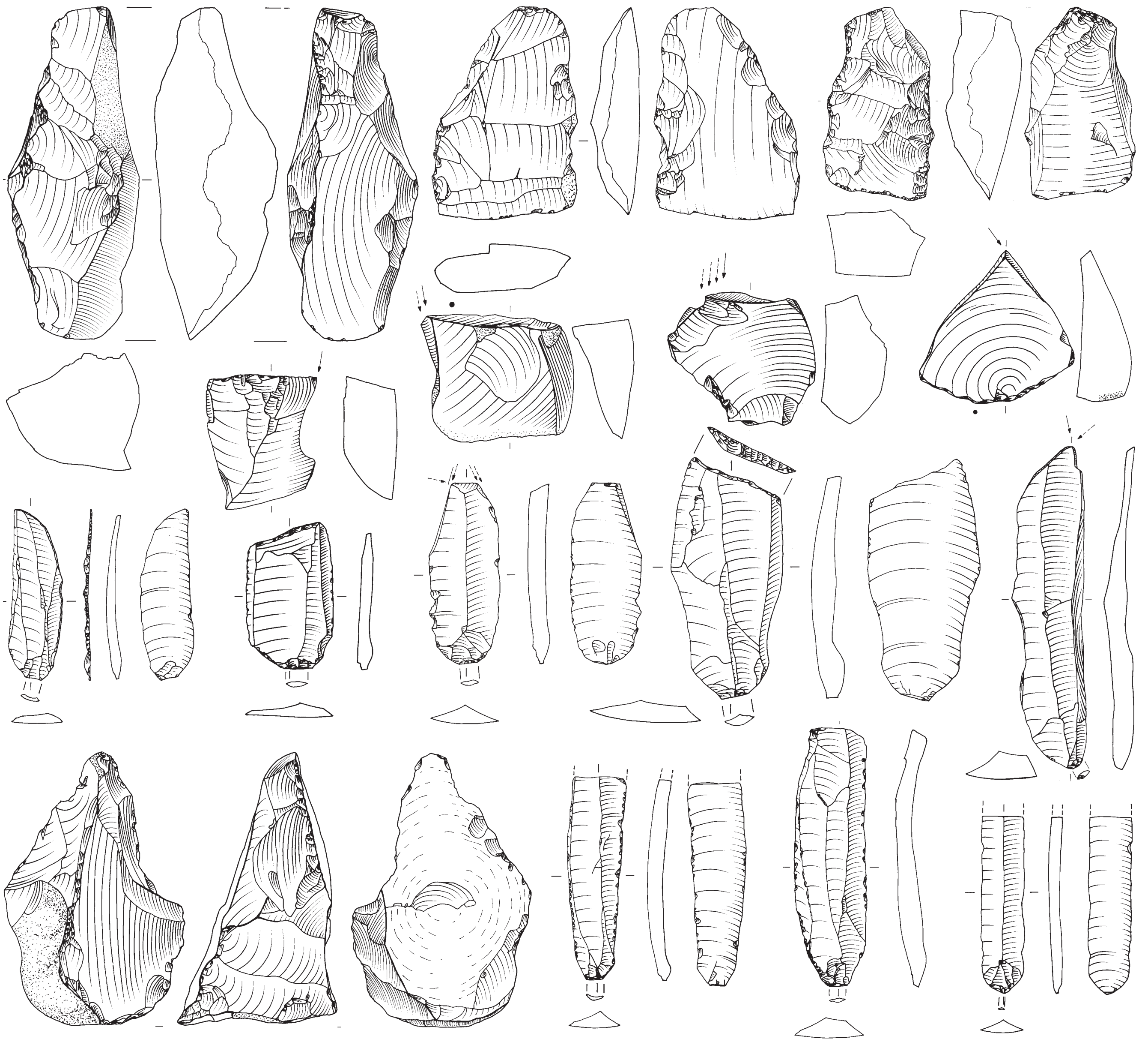


Figure 3.8: Jäckelgrund-Orth. Flint artefacts. 1 core adze; 2–3 flake adzes; 4–7 flake burins; 8–9, 11 oblique truncated blades; 10, 12 blade burins; 13 core borer; 14–16 partial edge-retouched blades (Drawings: J. Freigang; Scale 1:2)

sediments. Numerous marine shell remains were embedded even in the lowermost mud layers, just a few centimetres above the palaeolandsurface. Obviously the area was inundated at a time when the sea had already invaded the Wismar Bay area and started to transform it into a fjord landscape. In the section where the topsoil is almost laid bare, about a dozen tree stumps have been preserved in their original positions.

Two horizons containing archaeological objects were revealed in the test trenches. The first cultural layer was discovered in the fossil topsoil. Several flint artefacts, a few animal bones, and some fish vertebrae were found. The use of fire is indicated by burnt flint and fish vertebrae as well as a number of fired clay fragments. As the concentration of finds occupies only a small area, it is suggested that the assemblage represents the legacy of a short-lived camp. The dates of the tree stumps in the immediate vicinity suggest that the finds are attributed to the first centuries of the 6th millennium cal BC, when the Baltic Sea inundated Wismar Bay.

A second cultural layer was recognized in the upper marine mud layers. Apart from a large quantity of charcoal, it contained bones, mainly from large mammals, as well as numerous fish remains. These finds probably originated from

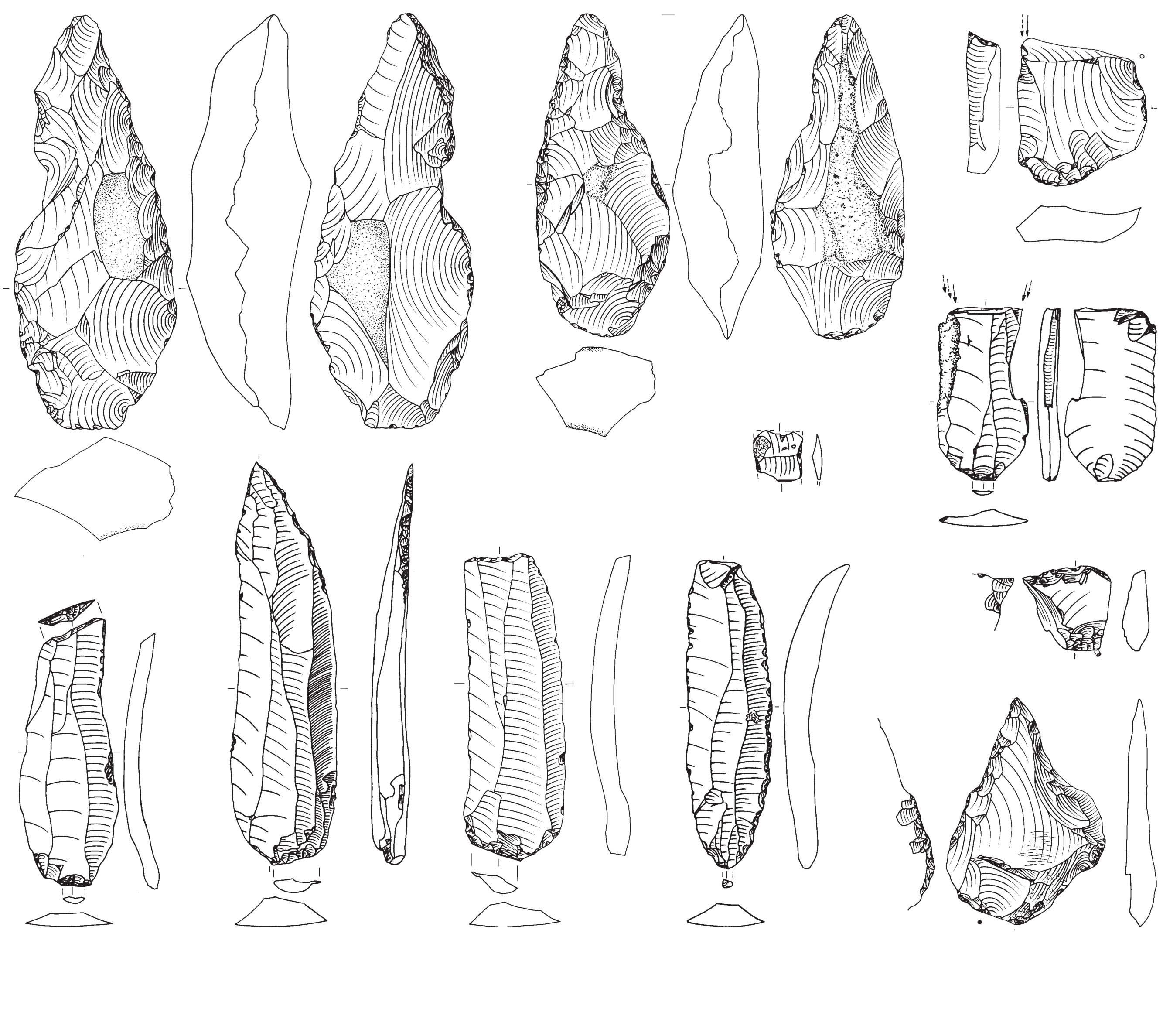
the shore where a second, younger settlement site was likely to have been present in the vicinity. This preliminary hypothesis, however, has not yet been confirmed by radiocarbon analysis.

The flint inventory consists of numerous cores, flakes, and soft-hammered macroblades as well as a couple of microblades (Fig. 3.8). Although the blade and flake tools still comprise blade burins, these are no longer as prominent as at the earlier site of Jäckelberg-Huk. Instead, there are several flake burins that have been truncated or broken. Scrapers are made from flakes and blades, and edge retouch and truncation are present. Among the heavy-duty tools, core adzes with a pointed-oval cross-section predominate. They are complemented by atypical, flat-trimmed flake adzes and a core borer. Unfortunately, projectile points, which would have been crucial for a more detailed typological comparison with contemporary Danish sites dating to the Villingebæk phase of the Kongemose Culture, are still missing. A worked boar tusk and an antler punch were also identified among the tools.

Jäckelberg-Nord

The site of Jäckelberg-Nord (Poel/Neuburg 16, Ostsee II) is situated immediately opposite Jäckelgrund-Furt on the other side of the small channel. It was discovered in 1999 during the first joint ship expedition of marine geologists from the Institute for Baltic Sea Research and archaeologists from the State Authority for Archaeological Heritage (Lübke 2002, 2003). It is located at 6–7 m below present sea-level on the edge of an organogenic sediment bank, which consists of limnetic gyttja overlain by marine mud. These layers must have been deposited when the Baltic Sea increasingly flooded the

Figure 3.9: Jäckelberg-Nord. Flint artefacts. 1–2 core adzes; 3 flake burin; 4 transverse arrowhead; 5 blade burin; 6–7 obliquely truncated blades; 8 straight truncated blade; 9 edge-retouched blade; 10–11 flake borer (Drawings: J. Freigang; Scale 1:2)



former valley. The investigations at Jäckelberg-Nord involved the mapping of the sediment bank and the recording of surface finds as well as the excavation of some small test trenches. However, the investigations made clear that only the part of the refuse area that had once lain in the shallow water some distance from the former shoreline has been preserved, and therefore contained only a few archaeological finds. Most of the actual settlement site with its adjoining shoreline has been destroyed by erosion (cf. Fischer, this volume).

Nevertheless, the remaining sediment on the seafloor has yielded a large number of flint artefacts (Fig. 3.9). These again comprise numerous blades that were made by indirect soft hammering. Apart from edge-retouched forms, the blade implements are dominated by pieces with a straight truncation, obliquely truncated knives, and blade burins, while flakes were primarily manufactured into borers and in some instances also into burins. In addition to one burnt fragment of a transverse arrowhead, some core adzes and flakes from the manufacture of their cutting edges do occur, while there are no indications for the use of flake axes.

Some wooden posts were observed in the vicinity of the preserved palaeoshoreline (Klooß 2010: 376); they probably belonged to a fishing fence structure (cf. Pedersen 1995; Fischer 2007). However, most notable is an axe haft that consists of the fragmented half-sleeve with an enlarged head and a rectangular recess for the handle (Lübke 2004: fig. 8; Klooß 2010: 191). It can be compared to the rare finds from Vedbæk Boldbaner, Margrethes Næs or Segebro in Scania, Sweden, which are attributed to the Kongemose and early Ertebølle Culture (Brinch Petersen *et al.* 1977: 157; Myrhøj and Willemoes 1997: 161, fig. 3). Eight objects were selected for radiocarbon dating. The calibrated mean values range over *c.* 400 years, between 5500 and 5100 cal BC. Thus, it can be concluded that the settlement site of Jäckelberg-Nord was occupied during an early phase of the Ertebølle Culture.

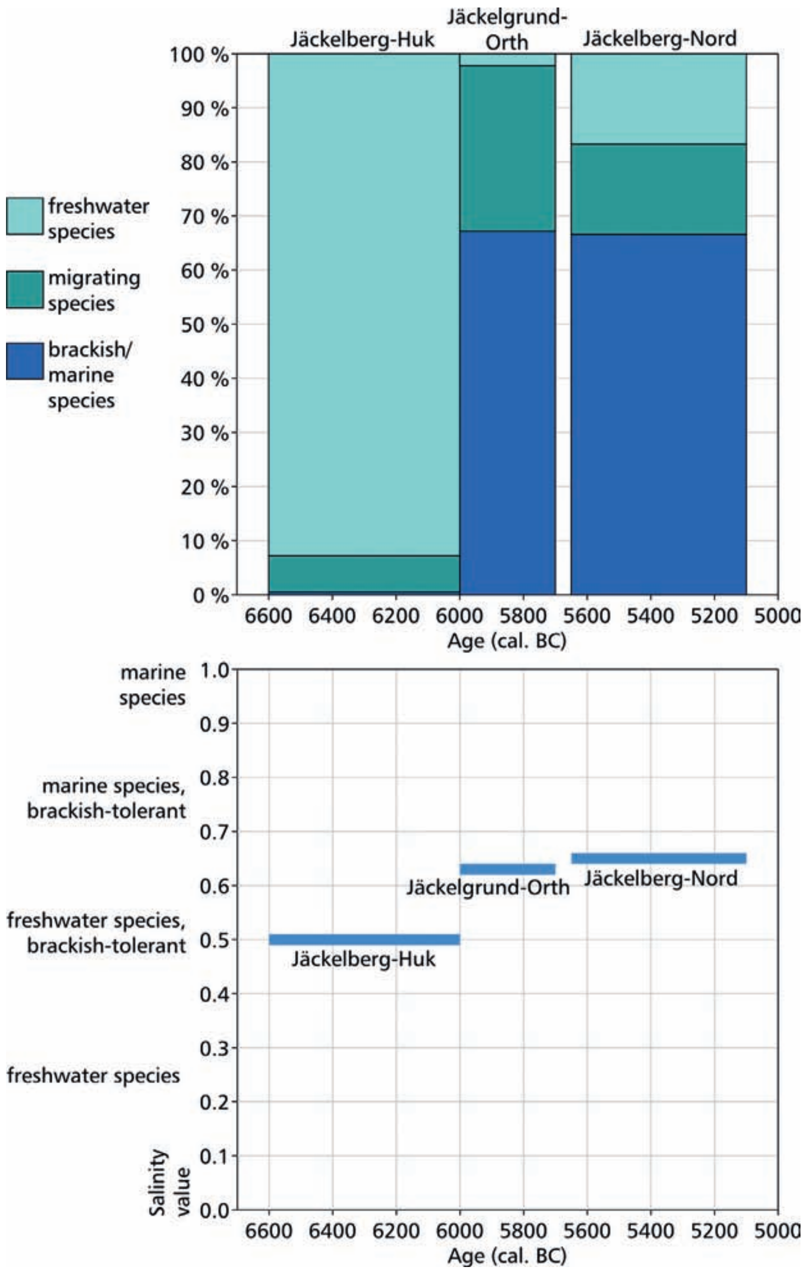


Figure 3.10: Succession of the fish fauna in the Jäckelberg area. Above: Frequency of the species groups 'marine', 'migrating', and 'brackish/freshwater' at the three sites based on the number of identified specimens. Below: Development of the salinity index created on the basis of the fish species community (for methodological details see Schmölcke and Ritchie 2010). Although the proportion of marine species is lower at Jäckelberg-Nord than at the older site of Jäckelgrund-Orth, the index points to a still increasing salinity

Archaeozoology

Jäckelberg-Huk

Jäckelberg-Huk, one of the oldest sites in Wismar Bay, is essential to understanding the onset of the Littorina transgression in the southern Mecklenburg Bay. As already mentioned above, the sediments show that the settlement was located on a small river near its outlet into a freshwater lake. During the main period of occupation the recorded fish remains, strongly dominated by perch (*Perca fluviatilis*), provide no evidence for fishing in a potential marine or even brackish environment (Fig. 3.10). Of 2197 identified fish remains, 99.8% belong to freshwater or migrating species. However, four

	Poel/Neuburg 45		Poel/Neuburg 42		Poel/Neuburg 16
	NISP (n)	NISP (%)	NISP (n)	NISP (%)	NISP (n)
Freshwater species					
Perca fluviatilis	1340	61.0	1	0.2	3
Cyprinidae	304	13.8	8	1.5	1
(*Rutilus rutilus*	5	0.2	1	0.2)	–
(*Scardinius erythrophthalmus*	2	0.1	1	0.2)	–
(*Tinca tinca*	3	0.1)	–	–	–
(*Abramis brama*	–	–	–	–	1)
Esox lucius	386	17.6	–	–	–
Migrating species					
Anguilla anguilla	122	5.6	162	29.9	4
Coregonus sp.	24	1.1	2	0.4	–
Salmo trutta	–	–	2	0.4	–
Marine species					
Pleuronectidae	7	0.3	19	3.5	1
Gadus morhua	4	0.2	299	55.1	10
Clupea harengus	–	–	43	7.9	4
Zoarces viviparus	–	–	4	0.7	–
Belone belone	–	–	–	–	1
Total sum	2197	100	542	100	24

Table 3.2 (left): Fish species identified at Jäckelberg-Huk (Poel/Neuburg 45), Jäckelgrund-Orth (Poel/Neuburg 42), and Jäckelberg-Nord (Poel/Neuburg 16). NISP: numbers of identified bones

Table 3.3 (below): Number of identified mammal bones at Jäckelberg-Huk, Jäckelgrund-Orth, and Jäckelberg-Nord

	Poel 45	Poel 42	Poel 16
game			
Cervus elaphus	22	4	3
Sus scrofa	2	9	4
Bos primigenius	1	2	1
Capreolus capreolus	13	2	–
Carnivora			
Felis silvestris	2	–	–
Martes martes	–	1	–
Canis lupus (f. familiaris?)	–	1	–
Vulpes vulpes	–	–	1
sea mammals			
Phocidae	2	–	–
(*Halichoerus grypus*	1)	–	–
micromammals			
Arvicola terrestris	37	1	2
Erinacaeus europaeus	2	–	–
Muridae indet.	–	1	–
Clethrionomys glareolus	–	–	1
Total sum	81	21	12

bones of cod (*Gadus morhua*) from the uppermost excavated layer complete the assemblage. They indicate an ecological shift during the last phase of occupation (Table 3.2). In all, the fish species identified show a community of freshwater-affiliated but brackish water tolerant species living in vegetation-rich water with a muddy bottom (Fig. 3.11). The recorded species could have lived both in a lake and in a slow-running river. It is remarkable that two pike (*Esox lucius*) bones already exhibit brackish or even marine $\delta^{13}C$ values (Table 3.1). This could mean that the marine flooding of Wismar Bay started before 6000 cal BC. However, the influence of a reservoir effect is unknown (cf. Fischer *et al*. 2007). The high number of bones from water vole (*Arvicola terrestris*) supports the reconstruction of a water-rich environment, since it indicates especially moist shores of waters covered by vegetation.

The most important vertebrate remains from Jäckelberg-Huk are from two seals (Phocidae): a molar of a juvenile grey seal (*Halichoerus grypus*) and a fragment of a scapula of an unidentifiable seal (Table 3.3). These findings show the appearance of the Baltic Sea transgression in the settlement locality *c*. 6000 cal BC (KIA-26398

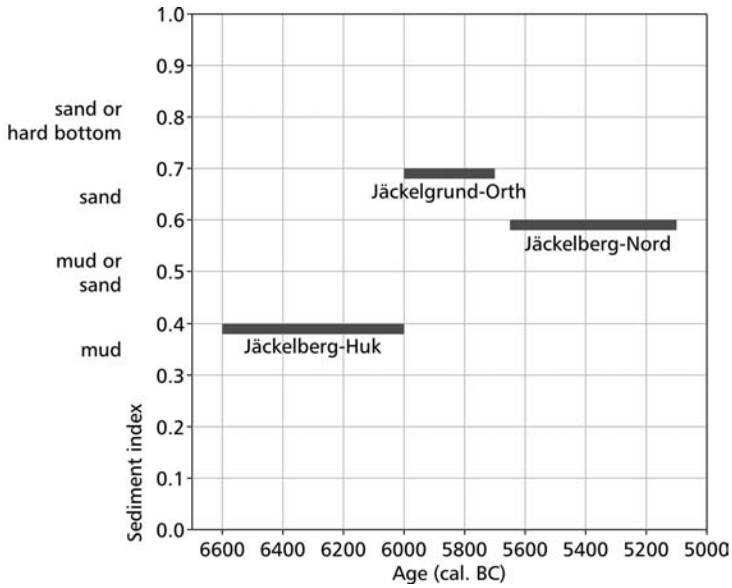


Figure 3.11: The analysis of the fish species community at the Jäckelberg site indicates a muddy sediment in front of the site of Jäckelberg-Huk, whereas the fish faunas from Jäckelgrund-Orth and Jäckelberg-Nord indicate a sandy environment

and KIA-31533; however the reservoir effect should be considered). They are among the oldest records of seals in the developing Baltic Sea (cf. Schmölcke 2008). The other mammal species recorded such as red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and hedgehog (*Erinacaeus europaeus*) are ubiquitous woodland species.

Jäckelgrund-Orth

Both the fish species present and the frequency of the species recorded verify the interpretation that the Littorina transgression had definitely reached the Jäckelberg area by the beginning of the 6th millennium cal BC. By then, Cod (*Gadus morhua*) was the most frequent species, representing about 55% of the bones identified (Table 3.2, Fig. 3.10) and freshwater species were in the minority (1.7%). In all, the fish list becomes relatively short, including only ten species. Apart from cod, eel (*Anguilla anguilla*) was the Mesolithic inhabitants' favourite marine food; together these species constitute 86% of the fish remains. This number can be interpreted as an indication of a selective fishery, although the very high number of eel vertebrae, in comparison to other fish species, makes such a conclusion difficult.

In spite of the small number of mammal bones (Table 3.3), the vertebrate material from Jäckelgrund-Orth provides the characteristic game spectrum known from many Central European Mesolithic sites: red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), and aurochs (*Bos primigenius*) were hunted. These species are typical for the landscape in the Atlantic period with its mixed deciduous forest, and as such were sought by humans as game.

Jäckelberg-Nord

The small fish species spectrum of Jäckelberg-Nord is dominated by marine species with some supplementary freshwater and migratory fishes (Table 3.2, Fig. 3.10). The species community documents brackish–marine conditions at this site and a bottom composition of mud or sand (Fig. 3.11). The mammal fauna is exclusively terrestrial and with the presence of the same large game species it does not show significant differences compared to the later site (Table 3.3).

Conclusions

Archaeological interpretations of material paired with scientific environmental assessments and radiocarbon dates have allowed for the reconstruction of the topography and environmental history of the drowned landscape near the Jäckelberg. This area is of particular interest since the coastline changes at the beginning of the Littorina transgression can be studied in detail in Wismar Bay (cf. Lampe *et al*. 2005, 2007; Jöns *et al*. 2007). The applied geophysical methodology used to localize features on the seafloor with the aid of side-scan sonar surveys and newly developed processing and post-processing of raw sonar data, enabled the identification of numerous organic sediment outcrops, partially with *in situ* tree trunks/stumps. Furthermore it was an important basis for the discovery of several drowned Mesolithic settlements in deeper water, some with well-preserved organic remains that are useful for dating and reconstructing the palaeoenvironment. This therefore represents a tested methodology, which can be considered to be a tool for future research on submerged prehistoric landscapes and settlements in the Baltic.

The scientific results clearly demonstrate how this area evolved from a freshwater inland environment with low marine influence *c*. 6000 cal BC, to a fjord landscape, and finally to the open bay found today. The profound transformation of the ecosystem in the area around Jäckelberg that took place when the rising sea drew near is impressively reflected by changing proportions

of the fish species found to have been exploited. While the inhabitants of Jäckelberg-Huk fished mainly for freshwater species, only a few centuries later their descendants at Jäckelgrund-Orth caught salt water fish almost exclusively. The area around the Jäckelberg was affected by transgression shortly after 6000 cal BC, between the occupation of Jäckelberg-Huk and Jäckelgrund-Orth. However, Jäckelberg-Huk, with its discrepancy between the freshwater fish and the brackish conditions indicated by their $\delta^{13}C$ values, demonstrates the difficulty in specifying an exact date for local marine inundation.

It seems that the Littorina transgression was not a catastrophic event in the Jäckelberg area, but a process that took place over perhaps a number of decades (Schmölcke *et al.* 2006). The landscape slowly changed over a slow succession from a deciduous woodland with lakes, to a spacious marshland of reeds, and finally to a marine ecosystem (Schmölcke 2005). During that time the humans would have had to adapt to the changing habitat. Apparently, the exploitation of the new fish species did not present a major problem to the Late Mesolithic population, while the acceptance of completely unknown marine animals seems to have been a rather slow process. Although individual seal bones were found at the earliest site of Jäckelberg-Huk, the hunting of marine mammals appears to have played a minor role during the entire Late Mesolithic period, since the faunal remains from all sites are dominated by typical forest animals such as red deer, roe deer, wild boar, and, in some cases, aurochs. It was not until the Terminal Mesolithic that the proportion of sea mammals started to rise, and subsequently became dominant during the final phase (Jöns *et al.* 2007; Schmölcke *et al.* 2007; Schmölcke 2008).

It is suggested that the Late and Terminal Mesolithic communities did not experience the environmental changes caused by the rapidly rising sea level as a major threat to their habitat. Rather, they would have been perceived it as a challenge or even new opportunity to take advantage of an altered environment. Moreover, archaeo-typological comparisons show that the groups living on the present German Baltic coast belonged to the Kongemose and Ertebølle cultures, which occupied the entire southern Scandinavian region. Therefore, as part of a greater regional culture, they did not have to create their own localized techniques in order to exploit marine resources. The requisite knowledge could have been adopted from their neighbours to the north who had developed their skills on the shores of the Kattegat centuries earlier.

Acknowledgements

The authors would like to dedicate this chapter to the memory of marine geologist and sedimentologist Dr Wolfram Lemke, senior scientist at the Leibniz Institute for Baltic Sea Research Warnemünde, who passed away at the age of 50 in April 2005. We lost not only an excellent scientist and colleague, but also a good friend. He was the *spiritus rector* of the interdisciplinary research presented in this chapter. The greatest tribute we can give to Wolfram is to remember his enthusiasm and to continue the research in his spirit. In addition, we should like to thank Martina Heineke, Institute for Coastal Research at GKSS, Geesthacht, who kindly provided the raw bathymetric data, based on multibeam echo sounder surveys, presented in Figure 3.7, and two anonymous reviewers for their comments on an earlier draft of the chapter.

Notes

1. GUV-R 2112 – *Regeln für den Einsatz von Forschungstauchern*
2. In the inventory of archaeological sites for the State of Mecklenburg-Vorpommern, the coastal area is divided from east to west into seven districts, Ostsee I to Ostsee VII, which are administrative units equivalent to a county on land. Most of the sites in Wismar Bay fall into the district known as Ostsee II. Thus, for example, the official name of the site of Jäckelberg-Huk is 'Poel/Neuburg Fpl. 45, Ostsee II'.

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4

The Unappreciated Cultural Landscape: indications of submerged Mesolithic settlement along the Norwegian southern coast

Pål Nymoen and Birgitte Skar

A detailed study of field reports, published and unpublished data from archaeological and natural science investigations has been compiled in order to present and document existing knowledge of submerged Mesolithic settlement along the Norwegian coast, with a special focus on the south coast. The extended Norwegian coast has experienced complex patterns of shoreline displacement due to pronounced land/sea alteration caused by interactions of eustasy and isostasy after the last deglaciation. In three major regions along the coast the regression minimum, particularly during the Boreal chronozone, was below the present sea level. In these three regions – between Kristiansand and Stavanger on the south coast, between Florø and Vigra and into the fjords on the west coast, and along the outer coastline between Lofoten and Sørøya in the north – the existence of submerged Mesolithic settlement remains has been established. The discovery on the south coast of sub-sea peat layers, a potential grave site near Hummervikholmen, and an ornate pickaxe by Kirkehavn highlights the possibilities for uncovering sites with organic remains below present sea level. Investigations of such sites would greatly enhance our knowledge of Mesolithic lifeways and cultural adaptation in Norway, as organic remains are otherwise very rare at terrestrial Stone Age sites. Given the impact of rapid, modern, landscape interventions in southern Norway, systematic survey of the seabed is strongly recommended. Based on the case studies presented recommendations for further research are outlined.

Keywords: southern Norway, shoreline displacement, submerged landscapes, Mesolithic, burials, bone artefact

Introduction

At several places along the extended Norwegian coast there is potential for the discovery of submerged traces of the earliest settlement of Norway. Among professional archaeologists this has been known for some time, but very few investigations have been carried out for a variety of reasons. This chapter gives examples from Norway with a special focus on the southern coast, aimed at demonstrating the research potential and methodological challenges for submerged prehistory in Norway. The findings are seen in a landscape perspective, drawing attention to the research opportunities afforded by the archipelago and the presence of submerged peat layers.

The Mesolithic remains on Norwegian settlement sites above present-day sea level usually show little diversity and the find materials are a poor basis for understanding the complexity of the earliest settlement of Norway. Acidic soil conditions almost invariably mean that only

lithic material will be preserved. A wide spectrum of organic artefacts and ecofacts are often missing or very scarce. The development of humus is slow resulting in stratigraphy being difficult to identify and interpret by means of traditional archaeological methodology. Radiocarbon dating is often problematic at the oldest sites due to difficulties in establishing the exact context for a sample. These conditions of preservation can perhaps best be illustrated by the fact that soil accumulation during the past 10,000 years has been extremely slow, in many places only 10–15 cm. Post-depositional bioturbation and decomposition therefore often leads to difficulties in recognizing simple constructions, like hearths. Important site types for understanding the social and cognitive aspects of Stone Age society (e.g. grave sites) are almost entirely missing from the Norwegian Mesolithic record.

Although Stone Age research has developed considerably during recent years (e.g. Glørstad 2004; Bjerck 2008; Berg-Hansen 2009) there is a need for systematic survey and scientific investigations of sites that yield opportunities for recovering more information on the earliest post-glacial settlement of Norway. Therefore, attention is drawn to the vast potential for underwater archaeological research that has been documented so well, for example, on the west Baltic seafloor and in other areas surrounding the North Sea basin (e.g. Pedersen *et al.* 1997; Andersen 2000; Gaffney *et al.* 2007).

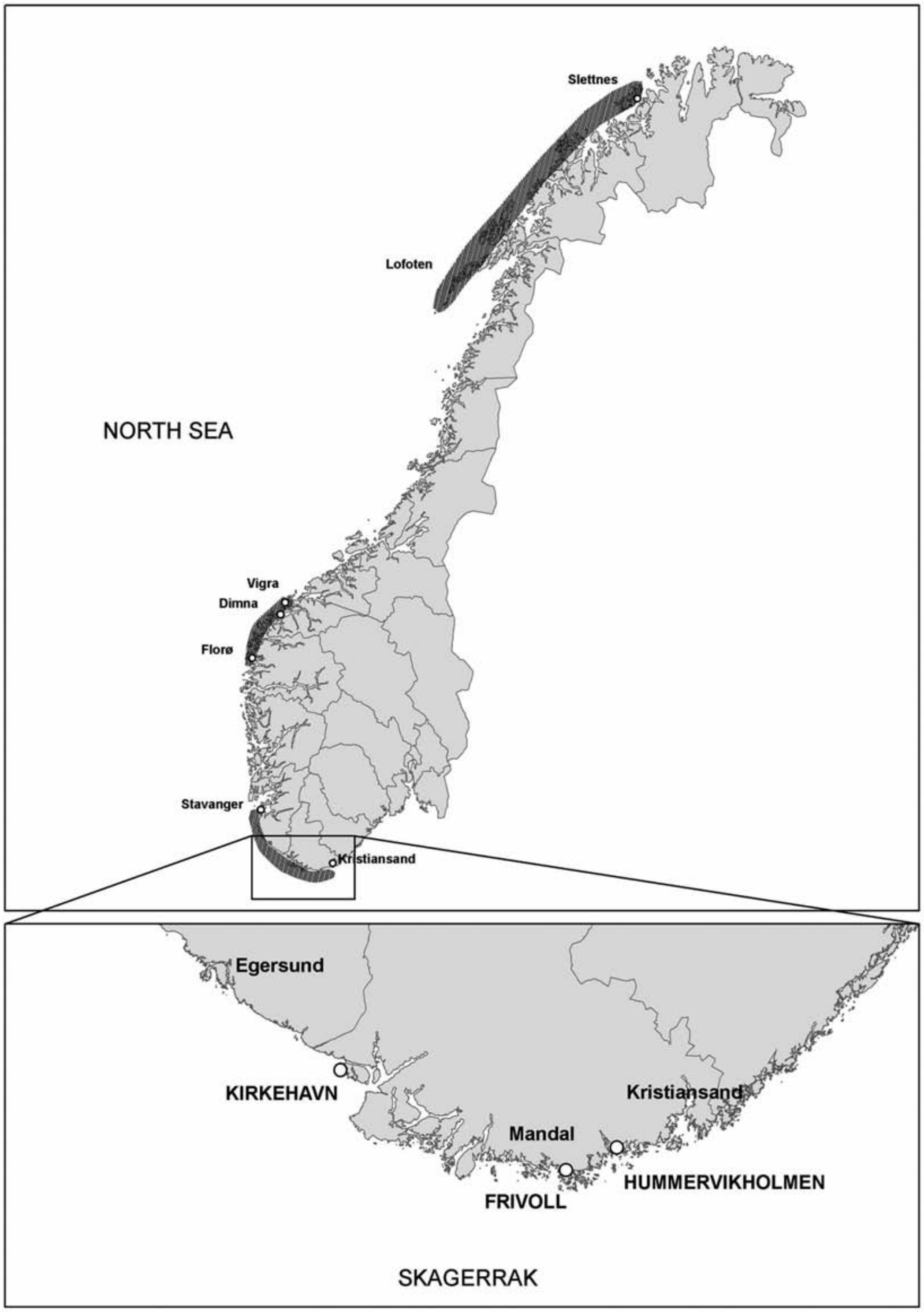
Post-glacial colonization and the geological conditions for recovering submerged Stone Age settlements in Norway

There has been a vivid discussion in Norway about whether the earliest immigration of people happened during the Younger Dryas or the Preboreal (Johansen and Undås 1992; Bang Andersen 1995; Bjerck 1995; Prøsch-Danielsen and Høgestøl 1995). The physical evidence points to a rapid colonization of coastal areas, covering the entire Norwegian coast over a period of less than 2–300 years during the early Preboreal (Bjerck 1994, 2008). There are, however, some indications in the southwestern parts of Norway of settlement reaching back into the later parts of the Younger Dryas. The artefact material recovered from the Galta site on Rennesøy in Rogaland (Prøsch-Danielsen and Høgestøl 1995) points to an Ahrensburgian coastal settlement, as does the palaeoshoreline dating of this site, which places the occupations between 11,150–9250 cal BC (11,200–9800 BP). The adaptation seen at Myrvatnet in Rogaland, representing systematic reindeer hunting in the mountain areas of southwestern Norway as early as 8950 cal BC (9600 BP) points to more permanent settlement within Norway at an earlier date. In addition there are stray finds of Bromme points from this part of the country, which raises the possibility of even earlier use of the Norwegian coast by hunter-gatherers originating from areas that are now under the North Sea (Rolfsen 1972; Hernæs 1979; Fuglestvedt 2005). While in the Oslofjord region the earliest stage of habitation recorded so far may be the recently excavated Preboreal site of Paulen I, which is shoreline dated to *c*. 9250 cal BC (9800 BP; E. Schaller, pers. comm. 2010).

The post-glacial shoreline displacement varies from region to region along the Norwegian coast (e.g. Hafsten 1983; Svendsen and Mangerud 1987; Bjerck 1995; Prøsch-Danielsen 1997; 2006). In the Oslofjord area the marine limit is 210 m above present sea level (Sørensen 1979). The post-glacial uplift was very rapid leaving a complete succession of prehistoric coastal sites above present sea level intact and unaffected by post-glacial transgressions. In other parts of Norway the succession of settlement, particularly during the Mesolithic, is more difficult to reconstruct owing to the influence of transgressions during the transition from the Younger Dryas to the Preboreal chronozone and the Tapes transgressions during the early Atlantic chronozone. Moreover, the Storegga tsunami dated to 6250–6100 cal BC (7350–7250 BP) affected at least part of the west coast (Bondevik *et al.* 1997). Particular geological conditions affording potential for the discovery of submerged Mesolithic sites exist in three areas: 1) the outermost coastline furthest to the north, 2) parts of the Norwegian west coast, and 3) the southwest coast (Fig. 4.1). While preservation conditions on the non-transgressed sites along the Oslofjord offer few possibilities for more precise dating (Bondevik *et al.* 1997), the early coastal sites along the west coast are often transgressed and heavily reworked by the sea.

A shoreline displacement curve was established in connection with the archaeological investigations at Slettnes on Sørøy in Finnmark in 1991 (Damm *et al.* 1993; Munch-Ellingsen

Figure 4.1: A map of Norway illustrating where the post-glacial regression minimum is below modern sea level, with detailed map of the south coast (Drawing: K Løseth)



1993). The curve indicates a post-glacial regression minimum at 8700–6400 cal BC (9400–7500 BP) at *c*. -5 m. A post-glacial regression minimum allegedly stretches from the outer coast of Lofoten to Sørøy in Finnmark (Møller 1989; Fig. 4.1). Underwater visual inspections in 1991 by one of us (Nymoen) indicate the presence of possible hut remains associated with a submerged beach ridge. On a beach ridge 4–5 m below the present shoreline several circular stone alignments that can be interpreted as house foundations, were also observed (Jasinski 1991; Trones 1992). Marine erosion had removed the covering sediments, leaving the structures intact.

At Slettnes two phases of settlement with similar structures were excavated on land along the modern shore; the oldest had been transgressed before a later settlement was established on reclaimed land after the Atlantic trangression (Damm *et al*. 1993). While the land-based sites were excavated, the sub-sea finds unfortunately were not investigated further (Wickler 2004).

Geological investigations along the west coast of Norway point to a similar situation for the area between Florø and Vigra (Svendsen and Mangerud 1987; Bondevik *et al*. 1997; Fig. 4.1). Recent archaeological investigations on this part of the coast confirmed the existence of a sub-sea Mesolithic site in a protected bay on the east side of the island of Dimna in Ulstein municipality (Nøttveit 2009). The shoreline displacement curve for the Dimna Strait indicates dry land down to -9 m at *c*. 8250 cal BC (9000 BP) while the curve further southwest by Borgundvåg on Stad indicates dry land at -20 m. According to Svendsen and Mangerud (1987) the early post-glacial transgression in this area is marked by a submerged beach ridge, while on Leinøy the regression minimum is assumed to be *c*. -12 m and the post-glacial transgression only appears as a stillstand or very slight eustatic rise between 10,900 and 9500 cal BC (11,000–10,000 BP; Svendsen and Mangerud 1987). This far western part of the present sub-sea landscape was thus dry land for an extended period from 11,900 to 6950 cal BC (12,000–8000 BP).

Along the southern and southwestern part of Norway from Kristiansand to Hafrsfjord by Stavanger, the post-glacial regression minimum was below present sea level during the Preboreal; by Egersund the sea level is established at -10 m during this time (Simonsen 1982; Bird and Klemsdal 1986; Prøsch-Danielsen 2006). The coastline beyond Jæren is, however, extremely exposed to the sea, and it is therefore less likely that sites are preserved *in situ*.

Further biostratigraphical investigations have recently been carried out between Mandal and Søgne on the south coast (Midtbø *et al*. 2000); the results of these have been integrated with earlier investigations in order to reconstruct a preliminary shoreline displacement curve for the area. These investigations indicate that outside Mandal the Preboreal/Boreal regression minimum was probably *c*. 5 m below present sea level, while a few kilometres further east in the Søgne area the regression minimum would have been down to -2 m. On Lista to the west the regression minimum has been calculated as -7 m (Midtbø *et al.* 2000), while the Atlantic Tapes transgression, which peaks in the Søgne area *c*. 5700 cal BC (6800 BP) would have reached *c*. 8 m above present sea level, rising toward the east and falling toward the west. However, analysis by Midtbø *et al*. (2000), which is based entirely on terrestrial basins, concludes that there is a need for further investigations in order to resolve the issue of the early post-glacial shoreline displacement for this part of the coastline. The methodology applied does not, however, allow for more precise positioning of the regression minimum.

The archaeological implications of the examination above are that in the marine zones under discussion, near the present coastline and in less exposed waters in the archipelago, there is potential for finding Mesolithic sites, in some areas dating back as far as the Younger Dryas. In contrast to sites above sea level, such submerged sites should have good preservation of organic materials (Fischer 1995; Andersen 2009), which would significantly enhance our understanding of the early colonization and settlement in Norway. Due to the Tapes transgression coastal settlements dating before the Atlantic period have been permanently flooded as relative sea-level rose and remained higher than during the early post-glacial period. During later periods the shoreline along parts of the coast was so stable that there may also be potential for retrieving well-preserved later prehistoric midden deposits or water-based installations.

Examples of submerged Stone Age finds along the south Norwegian coast

Although there has been an increase in underwater archaeological investigations over the past decade, few results have been brought to public attention. The following three cases address this issue:

Hummervikholmen

In 1994, the remnants of what would later turn out to be the oldest dated human skeletal remains from Norway were found at Hummervikholmen, a small island in the Søgne archipelago in Vest-Agder County (Sellevold and Skar 1999). The remains came to light as the landowner was using his boat's motor as a makeshift dredge to deepen the inlet outside his cabin. The compact bottom sediments worked loose and in this

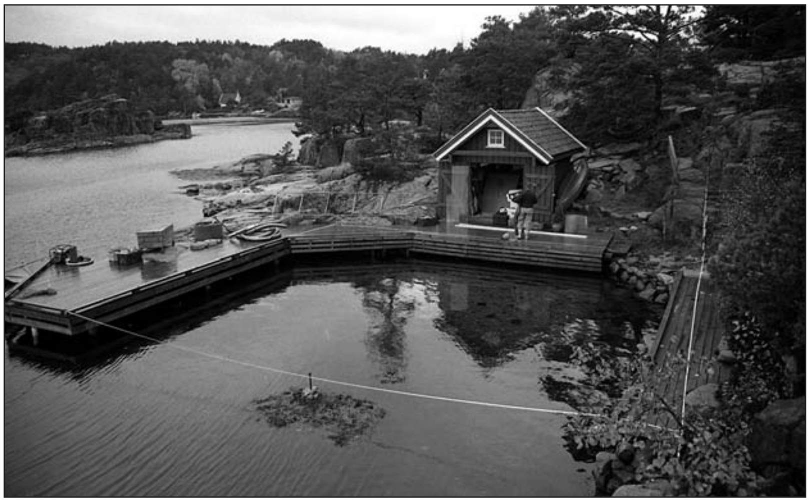


Figure 4.2: View of the inlet at Hummervikholmen, showing the location of the site and the boulder (Photo: Dag Nævestad, © NMM 1995)

way he managed to create a channel, excavating the seabed to a depth of 0.5–1.5 m. When the particles in the water settled the owner discovered what at first he thought was a jar, but which turned out to be an almost intact human skull. The skull was embedded in a compact, clayey, organic sediment layer.

During the 1994 and 1995 season, the Norwegian Maritime Museum (NMM) carried out minor underwater archaeological investigations in the inlet (Teisen 1994a; Kolltveit 1996; Sellevold and Skar 1999). The recent dredging had damaged *c.* 60% of the site, and a stone foundation for a quay and boathouse had disturbed the original beach zone (Fig. 4.2). The shallow sub-sea sediments had been partially removed down to bedrock. It was during the sieving of these redeposited sediments that several human bone fragments were recovered. At that early stage a preliminary biostratigraphical analysis based on samples from 1994 was performed (Prøsch-Danielsen 1996). However, the analysis turned out to be based on an incomplete stratigraphic sequence.

Most of the skeletal remains were recovered as stray finds owing to the recent disturbances. Only a large skull fragment, a tooth, and a thighbone appeared to be *in situ* when discovered in 1994 (Teisen 1994a; Sellevold and Skar 1999). We do not have conclusive information about the original depositional context of the other bones and fragments although, after assessing the effect of the boat disturbance, it is very likely that they originally occurred close to the cranium and thighbone.

At least three, but perhaps as many as five, individuals are represented in the material from Hummervikholmen, and the bone remains are very well preserved (Fig. 4.3). The assemblage consists of an almost complete skull (Individual 1), an occipital fragment (Individual 2), a frontal bone fragment (Individual 3 – determined from the ^{14}C date), an almost intact left femur, and a damaged left tibia. The two postcranial bones are gracile; it is not yet possible to state unequivocally which of these bones belongs to which individual, but both are from adults. The largest skull (Individual 1) is probably a female, *c.* 35–40 years of age at death. The skull is of medium breadth relative to the length, with a high upper face and rather low eye sockets. The skull is robust, resembling other Scandinavian Mesolithic female skulls (Bennike and Alexandersen 1997; Sellevold and Skar 1999).

Figure 4.3: All surviving skeletal fragments from the Hummervikholmen site (Photo: Beate Kjørslevik, © NMM 2010)

Sample	Context	Lab ID	^{14}C Age BP	Calibrated age BC (1σ)	Calibrated age BC (2σ)	δ^{13}C (‰)
Human – skull	Burial – Individual 1	TUa-1257	8600±95	7491–7255	7557–7117	-13.4
Human – occipital bone	Burial – Individual 2	TUa-2106	8635±75	7500–7327	7552–7191	-13.3
Human – femur		TUa-2107	8700±70	7554–7408	7580–7276	-12.6
Human – tibia		TUa-2108	8455±75	7282–7074	7417–6996	-12.9
Human – frontal bone	Burial – Individual 3	TUa-2105	8095±55	6761–6587	6918–6518	-13.6
Oyster	x 65, bottom of oyster bank	Beta-116099	7820±90	6423–6239	7526–6116	
Oyster	x 64, top of oyster bank	Beta-116100	7040±80	5646–5504	5730–5445	
Organic sediment	x 37, discontinuous thin organic layer (stratigraphically older than the oyster bank)	Beta-116098	8230±50	7339–7145	7451–7079	

Table 4.1: Radiocarbon dates from the Hummervikholmen site. Calibrations were performed with CALIB 6.0 (Stuiver and Reimer 1993; Stuiver et al. *2005) using the IntCal09 and Marine09 datasets (Reimer* et al. *2009). In applying a marine reservoir correction to the dates on mollusc shells and bone collagen, we have assumed a ΔR of -3±22 ^{14}C yr (Bondevik and Gulliksen 2006: 3243). The percentage of marine diet for the humans is estimated as 86% calculated by linear interpolation between the end-point δ^{13}C values -12‰ (100% marine) and -22‰ (100% terrestrial) for Individual 1.*

The Hummervikholmen finds have been dated by ^{14}C determinations on five bone samples from the dispersed skeletal parts. Four of the dates may be considered to be contemporaneous when the standard deviation is taken into account (Table 4.1). Although a marine reservoir correction has to be applied because of the heavy δ^{13}C values, these dates are still well within the Boreal chronozone, 8250–6950 cal BC (9000–8000 BP, Mangerud *et al*. 1974). The frontal bone belonging to Individual 3 appears to be somewhat younger than the other individuals. According to the Norwegian University of Science and Technology (NTNU) Radiocarbon Laboratory in Trondheim, the result makes it very likely that this bone belongs to an individual deposited *c*. 500–700 years later than the other remains from the site. The δ^{13}C values for all the dated fragments fall between -12.6‰ and -13.6‰ (Table 4.1), which indicates that more than 80% of the dietary protein of the individuals was derived from marine resources. An ongoing study involving further dating, δ^{15}N, and aDNA analyses will hopefully provide additional information on the diet and habitat of these individuals (cf. Fischer *et al*. 2007).

Assisted by the Danish National Museum's Marine Archaeological Research Centre at Roskilde, the NMM made a limited though more systematic investigation during the 1997 season (Nævestad 1997). The main purpose was to uncover the stratigraphic situation in the inlet as well as the depositional context of the finds. To ensure that samples for dating could be obtained from each layer, a profile was established running north–south from the inner part of the bay (at 43 cm below MSL) for 10 m toward the outer part of the bay (at 1.30 m below MSL) (Fig. 4.4). This profile was excavated down to sterile rock/moraine. Five distinct layers were identified, described here from the top down: 1) marine silty sand, 2) compact oyster bank, 3) clayey deposit with decomposed organic material, 4) intermittently occurring organic layer, covering 5) sterile moraine and/or bedrock.

Figure 4.4: A diver recording a profile at Hummervikholmen (Photo: Pål Nymoen, © NMM 1997)

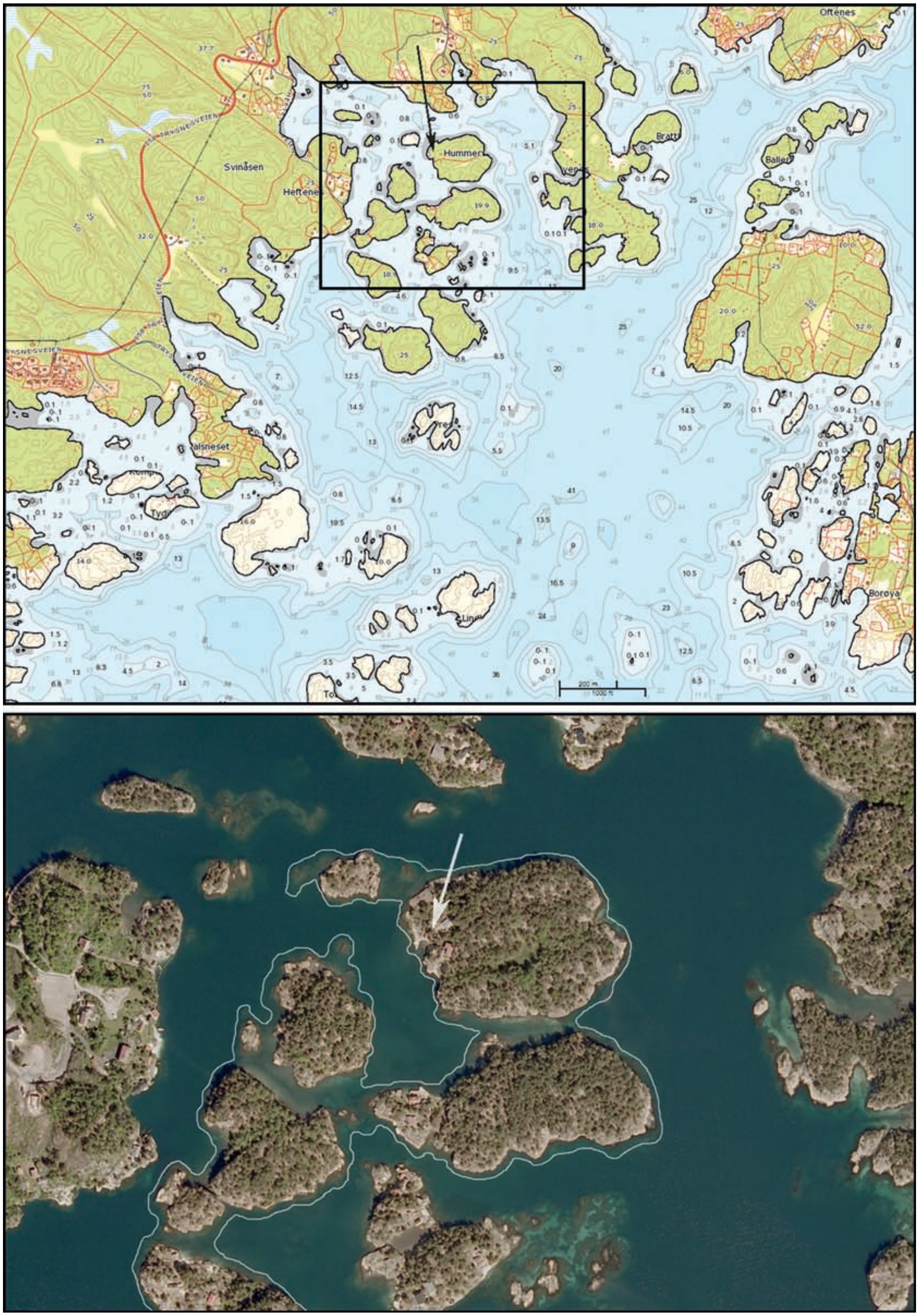


Figure 4.5: Above: The Søgne archipelago, Hummervikholmen, the site marked with arrow. Below: Aerial photo illustrating Hummervikholmen in the Søgne archipelago, site marked with arrow, the -2 m contour line is marked in white (Drawing: Pål Nymoen. Source: www.kulturminnesok.no)

From the oyster bank covering the skeletal remains two ^{14}C dates were obtained on oyster shell (Table 4.1): x 65 representing the bottom of the oyster bank, and x 64 representing the top of the oyster bank. The dates suggest the oyster bank would have been deposited during the Tapes transgression (Atlantic period) in relatively warm, calm waters. The discontinuous thin organic bottom layer (x 37) produced the cranium of Individual 1, a femur, and a tooth. A sample was

taken from this layer at a point *c*. 2.5 m from the skeletal remains and 55 cm from the top of the profile, at an absolute depth of 1.17 m. The ^{14}C age of the organic layer is younger than the skeletal remains found within it; however, since the calibrated age ranges overlap (Table 4.1), the dates are not significantly different.

The layer sequence at Hummervikholmen can perhaps best be compared with the Oddernes threshold, which is a peat locality lying at 3.75 m above MSL, *c*. 20 km northeast of Hummervikholmen. The locality was investigated in the 1950s by the palaeobotanist, Ulf Hafsten (1958). Hafsten discovered that the peat layer was overlain by 2 m of marine sediment representing the Tapes transgression. Based on pollen analysis he assigned the peat layer to the Boreal period, which traditionally is dated between 9000 and 8000 BP (Mangerud *et al*. 1974). The dating of the basal layer at Hummervikholmen may give a more precise indication of the beginning of the Tapes transgression in this area.

A boulder in the middle of the bay, where the inlet opens toward the sea, probably helped to protect the site during the Tapes transgression and subsequent storm events (Fig. 4.2). The dates from the oyster deposit suggest it most likely formed during the Tapes transgression. It is also clear that this layer was younger than the clayey organic sediment from which the skeletal remains derive. Assuming the individuals were buried on the contemporaneous beach, the thin organic layer represents a stratum where remnants of the late Boreal beach vegetation were washed out during the transgression. The human remains have thus been slightly redeposited. This could explain the anomaly of the somewhat younger date of the organic layer compared to the burials. Future biostratigraphical and archaeological investigations should help to clarify the sequence of events at Hummervikholmen.

Hummervikholmen is situated close to the mainland in an archipelago of more than a hundred islands and skerries (Fig. 4.5). The sea has varying depth, from narrow and shallow straits and bays, to deeper channels; today it is the habitat of many species of fish, shellfish, birds, and seals. Hummervikholmen is distinguished from the other nearby islands by having access to freshwater; being in the inner part of the archipelago it is well protected from the wind and there is minimal erosion from the current. Unfortunately, however, archaeologists seldom investigate such landscapes systematically.

During the Boreal period, which had a marine limit of 2 m below MSL (Midtbø *et al*. 2000), the landscape also had the character of small islands and skerries (Fig. 4.5). At that time several of the islands were connected, but the people living there undoubtedly would have had access to boats. The site was situated on a narrow lagoon and would have been protected from the wind and waves by islands to the south; this would also have weakened the effects of the Tapes transgression on the archaeological deposits. A large erratic boulder would have been a central element and contemporary marker of the landscape, and it is possible this had a special meaning for the Stone Age people. As the Tapes transgression progressed the boulder would have had an additional protective effect as a breakwater and sediment trap, and when the temperature rose during the Atlantic period conditions in the bay would have been optimal for the oysters whose remains seal the archaeological deposits.

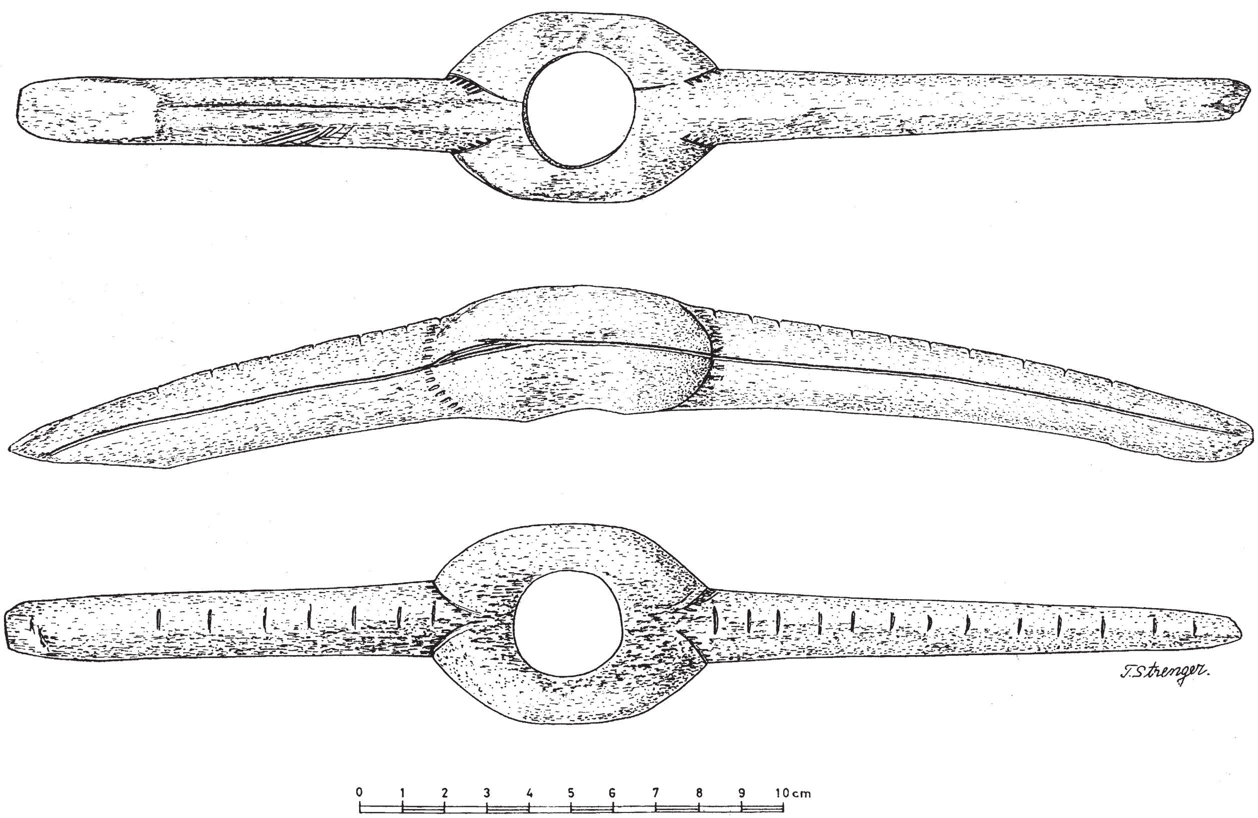
To date, Hummervikholmen is the most prominent submerged Mesolithic site in Norway. Unfortunately the site is now somewhat disturbed by dredging and sedimentation related to the construction of a quay and boathouse. The documentation and samples from the investigations in 1994–1997 are therefore important. These are now being studied and the results will be supplemented by further analyses of the human bone material, to be presented in a forthcoming publication.

Kirkehavn on Hidra

The finding of skeletal remains at Hummervikholmen in 1994 highlighted the potential of the coastal zone and the underwater landscape in Vest-Agder County as a source of new information about human populations and coastal adaptation. After the Hummervik site became known, NMM's attention was drawn to a very well preserved pickaxe that appeared to be made of bone or antler. The artefact was recovered by a local fisherman from peat sediments that had been removed from the harbour floor at Kirkehavn on Hidra in Vest-Agder (Fig. 4.6). The artefact is slightly curved. One end is slightly longer and has a rounded point while the opposite, shorter end of the pick is polished to a sharp transverse edge. The pickaxe is 293 mm long with a symmetrical hole 25 mm in diameter for attaching to a handle. The sides and the slightly curved upper surface

Figure 4.6: Aerial photo of Kirkehavn on Hidra (Source: www. kulturminnesok.no)

Figure 4.7: The Hidra pickaxe (Drawing: Tone S. Strenger)



are decorated with a geometric pattern of lines and notches (Fig. 4.7).

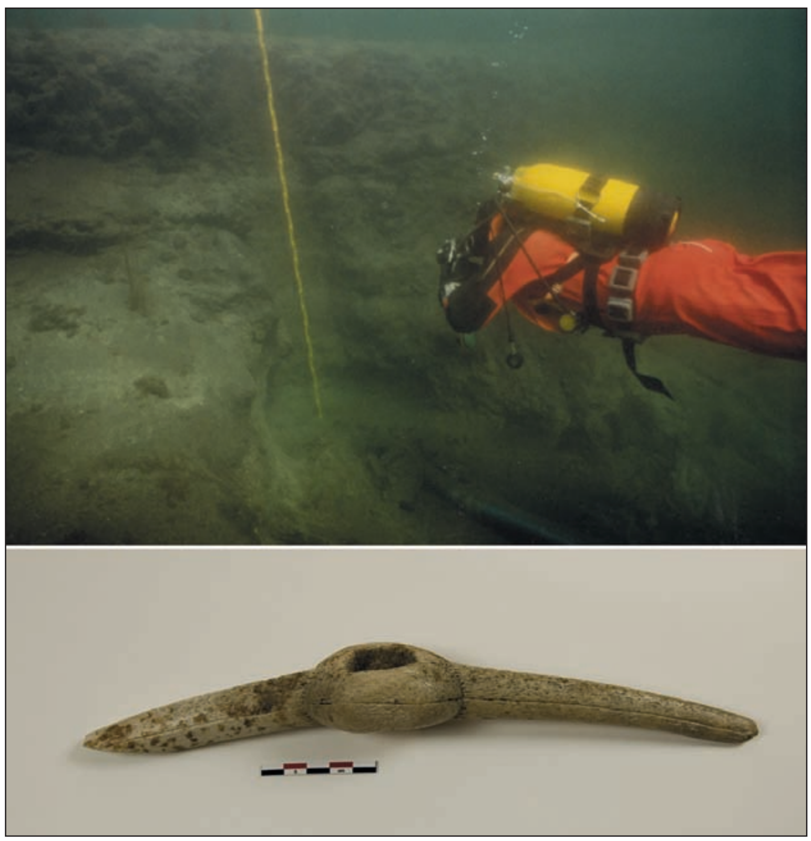
The pickaxe from Kirkehavn was found during the dredging of a peat layer in a shallow water zone. The $\delta^{13}C$ value (-16.6‰) suggests that the material most likely came from a marine animal. The artefact was dated to 8980±75 BP (TUa-1583), corresponding to a 1-sigma calibrated age range of 7811–7584 cal BC. Future DNA analysis will hopefully determine the species of the material used to make the Hidra pickaxe.

During a short survey of the site in the autumn of 1997 a peaty layer was observed extending from land at 0.5–1.5 m depth. Much of this layer had been removed by dredging when a fishing harbour was established. Although the exact provenance of the pickaxe in relation to the peaty layer is not known, a profile was excavated in 1998 in order to date the peat (Fig. 4.8). The results show the peat to be much younger than the artefact. A sample from the base of the peat was dated as 3120±60 BP (*c*. 1400 cal BC, Beta-116096), while the upper part of the peat was dated as 2560±70 BP (*c*. 670 cal BC, Beta-116097). No palynological analysis has been carried out. The peaty layer at Kirkehavn could therefore be a marine peat (cf. Sollesnes and Fægri 1951), although the presence of tree roots in the layer would seem to contradict this hypothesis. Recent underwater surveys have, however, located more intact seafloor layers with similar peat strata at other locations around Hidra. Whether or not there are peat strata around Hidra from the Mesolithic period is still unknown. Peat layers of this type, however, have potential for preserving artefacts of organic materials. The fishing harbour of Kirkehavn was established in 1990 and no archaeological underwater survey was conducted prior to the dredging operations, which removed as much as 70–80% of the original peat layer from *c*. 1.5 m to 6 m depth.

As almost the entire submerged landscape was removed during the dredging, and no other artefacts were found, we cannot know for certain if the pickaxe is part of a site or a chance find. It is possible that the artefact was lost during a hunting expedition. The state of preservation is extraordinary; the line decoration resembles ornaments on other known contemporaneous bone and stone tools (e.g. Vinsrygg 1979; Johansen 1992; Andersen 1996; Schilling 1997; Glørstad 1999). Examples of stone pickaxes resembling the Hidra axe are known from Aust-Agder. The cross-shaped axe from Gjerstad (Gjessing 1945: 222, fig. 69 no. 3) is one example; however, this tool was made from a soft limestone.

At the Botne II site in Rogaland, a peat layer dated to *c*. 5900 cal BC (7000 BP) produced eight fragments of shaft-hole tools made from stone. Glørstad (1999: 40) defined these as simple cross-shaped pickaxes with a biconical shaft-hole. From the damage and lack of use-wear on the majority of the tools, Glørstad (1999: 42) concluded that the artefacts were probably intentionally destroyed and thrown into the bog, which was by an estuary. Glørstad noted a remarkable connection in eastern and southern Norway between this type of tool and water, such that the artefacts are often found along the coast or in watercourses and rivers (Glørstad 1999: 45), and interpreted such tools as symbols of status; the find circumstances indicate sacrifice or demonstrations of power or affluence (Glørstad 1999: 59). The Hidra pickaxe discovery shares such traits and indicates that there was likely a rich and similar spectrum of artefacts made from organic materials. These tools may have been more commonly made from bone and

Figure 4.8: Above: Maritime archaeologist, Dag Nævestad, collecting samples from the peat layer on Hidra. Below: photo of the pickaxe (Photos: Pål Nymoen)



antler and less frequently from stone; the current record may be biased in this respect, owing to conditions of preservation. The decoration and advanced manufacture of the Kirkehavn pickaxe fits well with an interpretation as a status-weapon of great importance to the owner.

The discovery of the Kirkehavn pickaxe from Hidra is an indication of the potential archaeological resource of submerged sites, though the context of the later peat layers underlines the current lack of knowledge related to submerged landscapes.

Frivoll

While both Hummervikholmen and the Kirkehavn sites have been subject to very recent disturbances, there are examples of areas in Vest-Agder with a very high potential for well-preserved submerged Mesolithic sites. The site of Frivoll in Mandal has revealed Mesolithic material in a place where there have been few modern disturbances.

The Bay of Frivoll is situated 14.7 km west and 5.6 km south of Hummervikholmen (Fig. 4.1). Today the bay is narrow and shallow, and well protected in the inner archipelago on the landward side of the island of Skjernøya (Fig. 4.9). According to the most recent investigations the regression minimum at *c*. 8250 cal BC (9000 BP) was *c*. 5 m lower than the modern shoreline (Midtbø *et al*. 2000). The site is located near the narrow but deep (16 m) strait of Skjernøya, which is now an important artery for marine traffic along the inner coast between the mainland and the archipelago. The site is well protected and the landscape is characterized by features typical of a fishing site location (Fischer 1993, 1995). Attention was drawn to the locality in 1993 when flint artefacts were recovered along the seashore. It was later surveyed and debris from tool production was found at a depth of 1.75 m (Skar 1993; Teisen 1994b; Aarrestad 2005). No further systematic investigations have been carried out. The shallow bay has, however, been visited by archaeologists several times and some interesting observations have been made. In the shallowest part of the bay a layer of gyttja has been preserved. In the bay there is a thin marine sand layer, which is inhabited by snails, mussels, spiny cockle, and crabs that have disturbed the top 10–15 cm of the seabed sediments; otherwise very little disturbance is evident. The situation in the bay and the distance from deep water result in a combination of excellent conditions for preservation: low sedimentation rate, calm water, and minimal current and wave action.

Figure 4.9: Aerial photo of the bay at Frivoll. The find area of the arrowhead and debris marked in white (Source: www.kulturminnesok.no)

Artefacts were observed on the seabed lying in concentrations both along the shores and in the middle of the bay. The finds were concentrated 35 m from shore at *c*. 0.6 m depth; flint debitage and a small tanged point were found (Nymoen 2004). The point, which is 36 mm long and 16 mm wide, was made from a flake, the tang is on the proximal end, and no microburin technique had been applied. The tang is retouched on both sides, and a separate oblique retouch runs on the left side toward the point at the distal end; all retouch is from the ventral surface. The point is complete except for a very small break at the tip, and there are no signs of impact fracture (Fig. 4.10). The point type – termed A1 – can be dated to the Late Mesolithic or Neolithic, but there is also potential for a Preboreal date (cf. Bang Andersen 1990). There is a need for further systematic investigations in order to recover the entire toolkit and clarify the character of the site. Such investigations may reveal good conditions of preservation, as well as the possibility for combining archaeological and natural science investigations.

At many other locations on the south coast there are observations of submarine peat layers. These observations represent potential for

Figure 4.10: Tanged point from Frivoll, length 36 mm (Photo: Pål Nymoen)

more detailed geological investigations as well as archaeological surveys. Near Homsundø, Åptafjord in Farsund, a peat layer is known to exist at -2.8 m; wood from the layer has been dated to *c*. 8250 cal BC (9010 BP; Nævestad 2010). In Hølen in Farsund another submerged peat layer has been investigated, although no artefacts were found and the layer has not been dated. Near Espholmene in Flekkefjord, peat layers have been found at 3–4 m depth, although the layer has not been dated (Nævestad 2010).

Discussion

By compiling published and unpublished information, clear indications of the presence of submerged Mesolithic settlement have been demonstrated within three broader geographical regions along the expansive Norwegian coastline (Fig. 4.1). This is in line with the reconstruction of the local post-glacial shoreline. On the west coast between Florø and Vigra, in particular, there is potential for finding very old sites reaching back to the Late Glacial, given that well-protected locations can be found. Systematic investigations to locate areas with good conditions for preservation are recommended, and subsequent archaeological discoveries would greatly enhance our knowledge of the earliest settlement of Norway.

The formation processes along the coastline vary considerably. At Slettnes in Finmark there are indications of a flooded settlement area where the covering soil has been removed, but the house structures are intact. Along more exposed coastal zones, such structures would have been eroded. However, three case studies from the south coast indicate that one can expect preservation of organic layers in archaeological contexts under protected and favourable conditions.

Considering the southern region, the Hummervikholmen site alone has doubled the number of known human individuals from the Mesolithic in Norway. Although the site was recently disturbed, the findings bear testimony to the presence of a burial tradition in Norway during the Middle Mesolithic. The individuals would have been buried during the Boreal period at a time when the sea was up to 2 m lower than today. The graves would have been situated on the beach. At the time of the third individual's burial the sea would most likely have been much closer to the burial site during the period of the Tapes run-up. The $\delta^{13}C$ values for the Hummervikholmen individuals indicate a specialized coastal adaptation, and the time difference between the first and the last burial suggests a long-lived tradition at the site.

So far there are no signs that the dead were provided with grave goods, and surveys have not revealed any contemporary settlement site on the island. On the other hand, the boathouse, stone infilling for the quay, and the cabin are located in the most likely spot for a Stone Age site. The location in the archipelago offers many possibilities for settlement close by (Fig. 4.5). The very well preserved bone material yields an opportunity through scientific analysis to obtain a much clearer idea of the livelihood of the people who settled the south coast during the Boreal period. So far, about 60% of the bay near Hummervikholmen has either been investigated or disturbed. Nevertheless, there is a possibility that further investigations in the bay will reveal better preserved contexts, which would help to establish the character of the inferred burials. The Hummervikholmen site also has potential for geological investigations to improve our understanding of post-glacial sea-level changes.

There are probably a number of sites like Hummervikholmen site along this part of the coastline. The choice of settlement location is

ideal in terms of exposure and protection. The burials were flooded by the Tapes transgression *c.* 6950 cal BC (8000 BP). In the calm bay they were covered by an oyster bank, which both protected the site from wave action and provided good (alkaline) conditions for preservation of the skeletons. Finally, the boulder in the middle of the bay served to protect the deposits from erosion.

The submerged peat near Kirkehavn cannot presently be determined to be of terrestrial origin. There is a conflict between our present knowledge of the shoreline displacement curve and the dating of the peat, suggesting that the layer may be a marine deposit with accumulated driftwood and plant remains. The sediment has however provided optimal conditions for the preservation of a pickaxe made of bone or antler (Figs 4.7 and 4.8), and thereby has the potential to hold other important archaeological remains. Several submerged areas with peat deposits around Hidra offer research potential for both archaeological and biostratigraphical studies (Prøsch-Danielsen 1996). While Kirkehavn and Hummervikholmen are unfortunately disturbed by recent activities, Frivoll demonstrates that potentially undisturbed sites do exist.

Norway offers possibilities for studying sedimentation processes in regulated inland lakes or reservoirs controlled by a dam that are analogous to those in sheltered marine environments. Experiences from investigations of such water systems can prove important for developing a survey methodology and for determining the state of preservation on transgressed sites along the coastline. Localities situated between the highest and lowest regulated water levels are often stripped of turf, scoured, or completely removed depending on the degree of exposure. Sheltered sites, on the other hand, are often very well preserved as they have been covered by turf and sediment from surrounding areas. Such depositional processes have been studied in detail in the course of recent investigations in Aursjøen (Callanan and Svendsen 2006; Falck *et al.* 2007).

As mentioned above, there is some uncertainty and local variation pertaining to post-glacial sea-level displacement along the coasts of Norway. The establishment of the curves has often involved archaeological observations and are dependant on these interpretations being correct (Midtbø *et al.* 2000: 46). The present interpretations therefore assume a source-critical approach. In order to push this field of underwater archaeology forward, there is a need for goal-oriented and systematic studies involving both geologists and archaeologists.

The morphology and topography of the Norwegian coast varies a great deal from protected archipelagos to open exposed mountain ridges and moraine flats. The development of models for predicting site location must take this into account. The transgressions and later episodes have thus resulted in a diverse set of post-depositional phenomena. The character of the archaeological sites and their structures vary likewise; burials, like those at Hummervikholmen, would have been less exposed to a rising sea compared to fragile standing structures. The state of research on submerged Mesolithic sites in Norway should therefore be seen in light of these complex and relatively unexplored factors.

To date, there are no actual boat remains from the Mesolithic in Norway; it is, however, well established that sheltered harbours and landing places were an attraction for Mesolithic people. Although inland sites are known, the majority of Boreal sites are found along the former coastlines, indicating that people had a pronounced maritime adaptation. The use of boats (e.g. Bjerck 1995) would have been one of the most important prerequisites for marine hunting, fishing, and mobility along the coast and in the archipelago. The locations of sites, landscape analysis, and current knowledge of the Mesolithic coastal diet all confirm this assumption. It has also been suggested that certain artefact types, like the large numbers of stone axes on certain Mesolithic sites, may represent boat building artefacts (Stylegar 1999; Glørstad 2008; Østmo 2008). Whether the boat type was a logboat or a 'framework boat' (such as the kayaks and umiaks of the Inuits of the Arctic) remains unanswered. It is likely that both construction types existed, depending on access to raw materials and function (i.e. the differing needs for a watercraft to be sufficiently robust or seaworthy). We presume that the evidence for answering this question is still preserved in the submarine gyttya or peats associated with submerged Mesolithic sites in southern Norway.

None of the three sites from the south coast mentioned above was discovered by systematic survey. This fact illustrates the need to escalate and focus underwater archaeology particularly on locating submerged settlements. The present

situation must be seen in the light of how management and research has been organized. In Norway prehistoric archaeology has been the responsibility of the university museums; archaeologists from these institutions have had a terrestrial research focus, while the maritime museums have had a research focus on shipwrecks and the historic periods. This form of organization has led to unresolved responsibilities for underwater prehistoric material. In the future there is a need to strengthen the collaboration between the institutions involved, both concerning management strategies and in order to develop a common understanding of submerged prehistory.

Conclusion

On the south coast in particular a systematic survey of the seabed in shallow areas seems a viable option. From a thorough analysis of potential locations it should be possible to choose suitable areas for well-preserved sites. The chosen areas should be protected from the open sea, either behind islands in the archipelago or protected by local seabed topography. Sandy and clayey sediments should be given preference over rocky and gravelly sediments, and the presence of peat and gyttja is very important. The local exposure in relation to waves, currents, and tides is essential for good conditions of preservation.

Based on the examples presented we should like to emphasize that there are several reasons for focusing research efforts on the early post-glacial submerged landscape. The conditions for good preservation of prehistoric organic materials in the shallow bays protected by the archipelago can add substantially to knowledge of Stone Age society in Norway, and there is potential for finding new site types and installations that have not so far been recognized and preserved on land. Present knowledge of the cultural history of the Stone Age suggests that an independent Middle Scandinavian adaptation developed between 8250 and 6950 cal BC (9000–8000 BP) with distinctive toolkits and site structures (Skar 1993). The submerged sites located close to the present shoreline in three larger geographical regions of Norway span this period. Good preservation conditions potentially could lead to an enhanced dataset, which could be used to study the cultural development from north–south and west–east of the Skagerak–North Sea basin following the post-glacial recolonization of Scandinavia.

Today, especially in southern Norway, this particular coastline is very attractive for modern building. The construction and dredging associated with bridges, small harbours, and cabling are carried out as small-scale private enterprises without permission from the heritage authorities. This can lead to major destruction in the relevant zones. The western and northern coasts of Norway are exposed to further industrial activities associated with oil and gas extraction, offshore windfarms, sub-sea cables (all of which have associated onshore landing sites), and other large infrastructure interventions affecting the seabed. These offshore installations involve few investigations from the heritage authorities.

From both archaeological and geological perspectives there are still a number of unresolved issues concerning a more precise understanding of post-glacial coastal landscape development and use by prehistoric peoples. With climate change potentially causing more erosion, a collective effort is called for. It is of the utmost importance that such a project focusing on nearshore environments is carried out by an interdisciplinary group of archaeologists, geologists, and palynologists. This would enhance both the cultural and environmental knowledge base for designating areas of high potential for submerged Mesolithic deposits.

The current distribution of responsibility between institutions performing archaeological investigations represents a challenging environment for the management of submerged prehistory. There is a particular need for increased professional collaboration and improved systems for data sharing relating to submerged Mesolithic landscapes. Finally, there is a critical need to develop a common research agenda and methodology particularly suited to Norwegian conditions and the issues involved in locating submerged Stone Age sites.

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5

How Wet Can It Get? – approaches to submerged prehistoric sites and landscapes on the Dutch continental shelf

Hans Peeters

The number of archaeological and palaeontological finds from the Dutch coastal zone and North Sea has increased spectacularly over the past two decades, due largely to the efforts of a group of private collectors working closely with professionals. In spite of the advances made in understanding the scientific significance of these finds, little is known about the original stratigraphic context of individual finds and assemblages, since most of the material was recovered from fishing nets. Recently, however, several research projects focused on collecting contextual information have been initiated. Two such examples are the Rotterdam–Maasvlakte (Europoort) area, which is known for its Mesolithic barbed points and rich Pleistocene faunal assemblages, and the Middeldiep area, which is known for its Middle Palaeolithic artefacts and a fragment of a Neanderthal cranium. This chapter provides a brief account of these activities and discusses the current approach in The Netherlands to submerged prehistoric landscapes, which are considered to be of equal value to the now famous wetland sites.

Keywords: Netherlands, prehistory, Palaeolithic, Mesolithic, palaeontology, submerged landscapes, North Sea

Introduction

Large parts of The Netherlands are nowadays below sea level and this will increase with further climate change and sea-level rise. Modern technology permits us to prevent inundation, but clearly such management has only existed in historical times. In prehistoric times, sea-level rise and changing hydrology led to the creation of wetland environments. The gradual evolution of these wetlands since the end of the Last Glaciation has resulted in the development of peat and clay deposition, and the formation of complex stratigraphies. Wetlands are the product of the interplay of many factors. The development of wetlands is not unique to the Holocene; they have occurred throughout the Quaternary when environmental conditions were favourable for their development. However, in The Netherlands it is mainly Holocene wetland environments that are known as a rich archive of palaeoenvironmental and archaeological research. Not surprisingly, there is a long tradition of wetland research and over the past decade large-scale excavations at a number of Mesolithic and Neolithic sites (Louwe Kooijmans 2003; Peeters 2007) have again highlighted the importance of these areas as rich repositories of information.

Clearly, the modern-day wetlands were not always *wet* land. In fact, the thick layers of peat, mud, and clay cover dryland surfaces that were once used by prehistoric people, as were prehistoric wetlands themselves. The major practical difficulty, however, is how to reach these levels, which can be several to tens of

metres below the present land surface. On rare occasions opportunities have permitted closer examination and produced surprising results (cf. Louwe Kooijmans 2003; Peeters 2007). But wetland archaeology is still faced with some persistent problems. How do we get an idea of what may be down there? When do we know 'enough' in order to make well-founded choices in the context of heritage management, or to decide on costly excavations at great depth? Or, in the case of programmatic research, where should the attention be focused?

The issues facing wetland research are also applicable to submerged areas with the difference, however, that the layers of interest are underwater (Maarleveld and Peeters 2004). The southern North Sea, for instance, is well known for its rich palaeontological record, as well as for its finds of bone and antler implements dating from the Mesolithic. For the most part, this material has been caught in fishing nets (when exposed on the seafloor) or brought to the surface during aggregate extraction (cf. Tizzard *et al.*, this volume). Even when material is exposed on the seafloor, the general problem is that it is largely invisible because it is submerged. Geophysical remote sensing techniques lack the spatial resolution required to detect most prehistoric items, while systematic surveying by divers, or even robotic cameras, of larger areas is constrained by many factors (time, money, logistics, and visibility). Yet, as in the Dutch wetlands, it is acknowledged that the importance of offshore archaeological and palaeoenvironmental (palaeontological and palaeobotanical) materials cannot be underestimated (e.g. Flemming 2004; Peeters *et al.* 2009).

For a considerable period, the informational value of the many, often spectacular finds from the southern North Sea was somewhat restricted owing to the lack of contextual information. Through a more systematic approach to the collection of materials brought ashore by fisherman – an initiative taken by a group of amateur palaeontologists and archaeologists (Glimmerveen *et al.* 2004; Mol *et al.* 2006) – insights into the potential information value of these finds have increased spectacularly over the past decade. One of the major shortcomings in our understanding of the significance of the finds is the lack of data from the original stratigraphic contexts of the collected material,

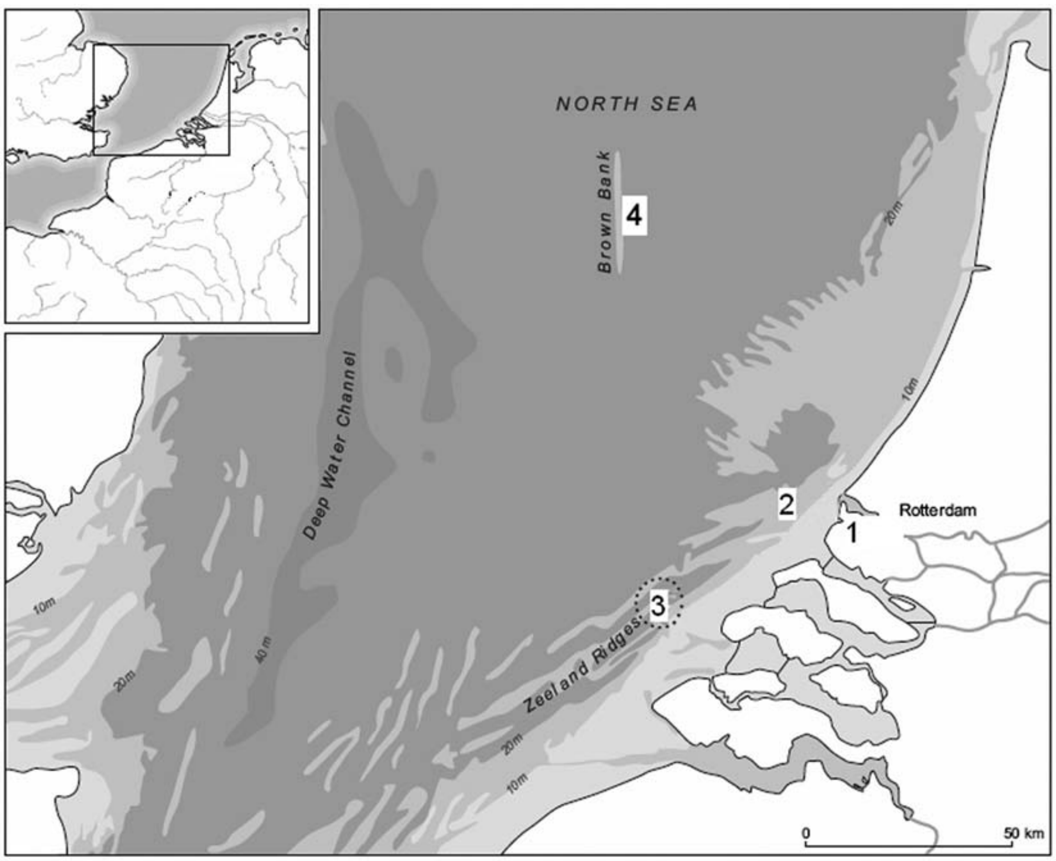

Figure 5.1: Geographical location of the main find areas mentioned: 1 Rotterdam Europoort–Maasvlakte, 2 Eurogeul, 3 Middeldiep, 4 Brown Bank

resulting in mixed assemblages spanning the Early Pleistocene to Holocene. The informational value of these mixed assemblages could be increased significantly if such contextual data could be attached to the individual components of these aggregate collections.

Having learned from onshore wetland research, the timing is right to shift attention to submerged prehistoric environments (Maarleveld and Peeters 2004). Several initiatives have recently been taken by Dutch researchers and heritage professionals to turn the overall negative assessment of research possibilities toward a more positive and inclusive approach. The main objective has been to collect contextual data, although we accept that spatial and temporal control among the observed phenomena may be less than on land. The initiatives relate to three settings (Fig. 5.1):

1. The Mesolithic barbed point 'assemblage' from the Rotterdam–Europoort (Maasvlakte) area (Louwe Kooijmans 1971; Verhart 1988).
2. The palaeontological materials from the Eurogeul off Rotterdam (Mol *et al.* 2006).
3. The Neanderthal frontal bone and flint artefacts from the Zeeland Ridges, off the Zeeland coast (Verhart 2004; Hublin *et al.* 2009).

The present status of these initiatives and their methodological approach are discussed here from a scientific and a management perspective. A brief overview of the research history in The Netherlands with regard to offshore prehistoric remains (palaeontological and archaeological) is also presented. This is followed by an assessment of potentials and opportunities, the current research approaches to the initiatives taken, and some initial results. Finally, aspects of heritage management, which is currently undergoing important conceptual changes with regard to the consideration of (submerged) prehistoric landscapes (Peeters *et al.* 2009), are described.

A brief history of research

With the publication of a number of bone and antler implements originating from the Brown Bank and Europoort/Eurogeul areas, Leendert Louwe Kooijmans' (1971) article must be considered the initial step for the continuous, yet fragmented attention to prehistoric archaeological remains from the submerged landscape of the southern North Sea. In spite of the absence of reliable contextual data and the lack of radiocarbon dates, no definite age could be assigned to these objects at the time. However, the combination of sea-level rise data and typo-technological considerations make a strong case for a Mesolithic age.

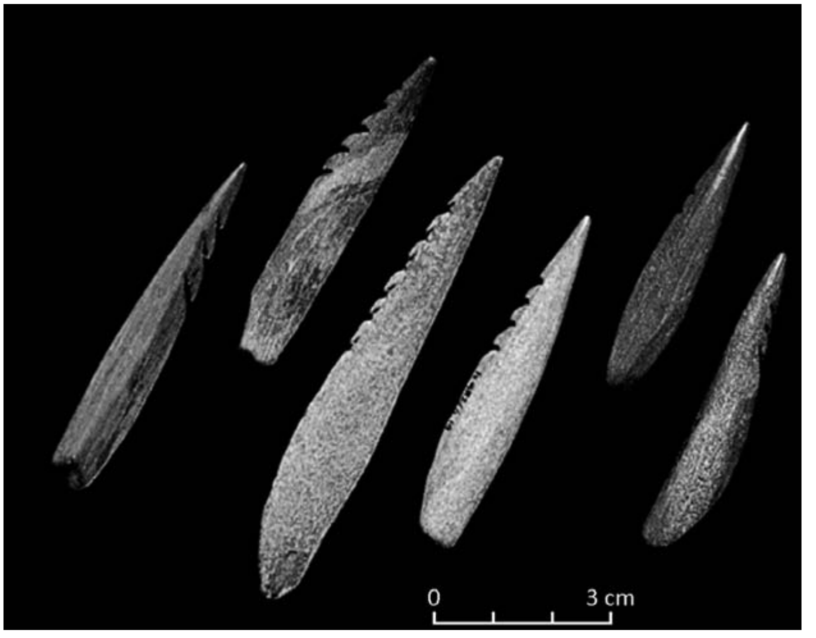

Figure 5.2: Barbed points from Europoort–Maasvlakte (Courtesy of the Rijksmuseum van Oudheden, Leiden)

Among the implements published by Louwe Kooijmans (1971) were numerous barbed points that came from the Europoort area, a piece of land reclaimed as an extension to Rotterdam harbour. Over time, hundreds of points of bone and antler have been collected (Fig. 5.2). This remarkable assemblage was extensively published by Verhart (1988) and, to date, over five hundred points are known. A small number of radiocarbon dates published by Verhart (1988) suggest a time-range from the Preboreal to the beginning of the Atlantic. Clearly, the material did not originate from a single context or layer. However, the sand used for land reclamation came from a relatively restricted area, broadly identifiable to a location just off the former coast.

At about the same time, palaeontologists increased their interest in the North Sea area, where fishermen frequently 'caught' bones (mainly of extinct Pleistocene animals, such as woolly mammoth, bison, and woolly rhinoceros) and fossil tree stumps. In the course of the past two decades, significant advances have been made in the approach to these fishing activities. Palaeontologists, including Dick Mol, Jelle Reumer, Klaas Post, and the late Paul Sondaar, recognized the importance of this material and

made arrangements with the fishermen. Instead of being thrown overboard or sold (a common practice that happened mostly with mammoth molars), bone remains as well as artefacts were collected and brought ashore. Not only did this permit initial assessment and selection of scientifically interesting pieces but, importantly, the possibility to register the geographical origin of the material.

Gradually it became clear that several areas were particularly rich in palaeontological and archaeological material: the Eurogeul (off Rotterdam), the Middeldiep (off the Zeeland coast), as well as the Brown Bank area. A number of targeted 'fishing' expeditions confirmed this picture. The Brown Bank area seems to be particularly important with regard to the Mesolithic and has yielded stone, bone, and antler artefacts along with Early Holocene faunal remains, as well as human bone material (Fig. 5.3). A number of AMS dates firmly place this material in the Preboreal and Boreal periods (Glimmerveen *et al*. 2004). Noteworthy are some Neolithic axe blades from the same area. The material from the Middeldiep is of particular interest for its Middle Palaeolithic component. A considerable number of handaxes and side-scrapers, as well as cores and Levallois flakes/blades have so far been recognized (Verhart 2001, 2004). More recently the same area produced a fragment of a Neanderthal cranial bone (Hublin *et al*. 2009). The Eurogeul seems to be of particular importance for its extreme wealth of Pleistocene mammalian remains (Glimmerveen *et al*. 2004; Mol *et al*. 2006). There are also some indications of human activity (Mol *et al*. 2006).

In view of these results, research in the context of 'Malta-related' projects in The Netherlands has begun to take this from simple potential to a serious point of departure. The 'Malta Act' as part of the Dutch legislation on cultural heritage states that those who (plan to) disturb the subsoil have an obligation to investigate whether this will have an effect on archaeological remains. There is an increasing awareness that valuable information can be gained from offshore contexts. It seems we are entering a new era of research in underwater archaeology in The Netherlands, which traditionally has focused on historical, maritime vestiges related to seafaring.

Potential and opportunities: from hypothetical 'worlds' to reality

The spectacular results over the past decade or more have led to a more general recognition of the scientific research potential of the North Sea basin (Flemming 2004; Peeters *et al*. 2009). Furthermore, major advances in the fields of geology and physical geography have demonstrated that vast swathes of palaeolandsurfaces remain preserved. The results from the analysis of seismic

Figure 5.3: Mesolithic finds from the Brown Bank area (cf. Glimmerveen et al. *2004). a) mace head; b) antler adze; c) human mandible (Courtesy of Dick Mol)*

data by Gaffney *et al.* (2007) are unparalleled. Research in the shallower waters off the Dutch and Belgian coasts has delivered promising results with regard to the possibilities for identification of geomorphological structures and reconstruction of palaeolandscapes (Rieu *et al.* 2005; Mathys 2009).

At present, the four areas mentioned above (Europoort, Eurogeul, Middeldiep, and Brown Bank) can be identified as major find zones in the Dutch part of the continental shelf. So, how are we to assess the research potential of these collections? Clearly, the finds themselves are valuable in that they provide some intrinsic information. Bones can be attributed to species, samples can be dated or analyzed for DNA, artefacts can be categorized and sometimes dated by radiocarbon, and so on. However, questions concerning relationships in time and space among items or groups of items cannot be addressed properly, even though a multidisciplinary approach, such as that initiated by Mol's group (Glimmerveen *et al.* 2004), may have started to provide some clues.

The developments in the field of geology and physical geography offer new perspectives for future research. Models of lithostratigraphy and geomorphological structure, no matter how coarse these may often be, have to provide the basic temporal and spatio-geophysical framework on which interdisciplinary strategies can be built. This is already being done in specific cases, for example area HAML240 in British waters off Great Yarmouth, where numerous Palaeolithic handaxes have been dredged up (Tizzard *et al.*, this volume), and in the cases of Eurogeul, Europoort, and Middeldiep.

The three initiatives listed in the Introduction have in common that, at the start of the research, very little information on the geological, palaeoenvironmental, and archaeological setting was available. Hence, research strategies had to begin with extremely fragmentary data, and necessitated the development of preliminary working hypotheses and bold assumptions about what might be expected. Of course, the real challenge is how to get a grip on the validity of these coarse models and how to refine them. In other words, how do we move from a primarily hypothetical 'world' to the real one? In the following section, the respective approaches are briefly described and some initial results are presented.

Contextualizing Early Holocene barbed points

The vast majority of the hundreds of Mesolithic bone and antler barbed points collected in the Rotterdam–Europoort area originate from reclaimed land for the first post-World War II extension of Rotterdam harbour. Even though the barbed points came from relatively localized deposits, only a rough guess could be made about which sedimentary units contained the many points (Louwe Kooijmans 1971; Verhart 1988). The most plausible option seemed to assume a relationship with the Early Holocene Velsen layer, consisting of fine-grained, humic sediments deposited in a slightly brackish, lagoonal environment.

Several years ago a second extension to the harbour area (Maasvlakte II) allowed for more targeted research (Maarleveld and Peeters 2004), and research questions were framed by The Netherlands Cultural Heritage Agency and the Municipal Archaeological Service of Rotterdam (Manders *et al.* 2008). From the outset, priority was given to research focused on the collection of contextual data. In view of the depth of the potentially interesting layers (*c.* 20 m below Dutch OD) chances of large-scale, site-focused sampling, were considered low. Further refinement of the strategy, however, is envisaged as new information becomes available over the course of the project. The research strategy in the context of Maasvlakte II involves the following stages:

1. A desktop study to inventory the available geological and archaeological data.
2. Development of a lithostratigraphic spatial model and palaeoenvironmental characterization.
3. Development of a predictive spatial model of archaeological potential.
4. 'Field' sampling.
5. Analysis, interpretation and synthesis of all data, and subsequent reporting of results.

Stage 1 was conducted prior to the start of any construction activity. The main result from the desk-based study and assessment of available coring data was the identification of a possible remnant of a vast Late Glacial aeolian river dune and the presence of fine-grained sediments – possibly the Early Holocene Velsen layer (Hessing *et al.* 2005). River dunes are not unique to the central Netherlands' Rhine–Meuse delta, but records of them become increasingly sparse westwards due to the restricted coring depth

relative to the depth of river dunes. Furthermore, the higher parts of the river dunes close to the shore have an increased chance of having been affected by marine erosion.

At present, the project is in the second stage of research where a number of activities have been scheduled in strict sequential order. First, all coring and pulse probing data have been assessed in terms of suitability (sufficient depth and quality/reliability). Secondly, the data have been analyzed and interpreted so as to provide a preliminary (rough) lithostratigraphical model. During the third stage, seismic recordings will be carried out in order to enhance the spatial resolution, while a number of new high quality vibrocores will be taken for the purpose of validating and refining the lithostratigraphic model. These cores will also be sampled for palaeoenvironmental analysis and radiocarbon dating.

The analysis and interpretation of the initial probe data delivered some unexpected results relative to the hypothesis generated by the desktop study (Vos *et al*. 2009). First, the expected river dune was not visible in the cone probe readings. The sandy substrate probably consists of Pleistocene fluvial deposits; aeolian sands seem to be absent. Secondly, the Pleistocene substrate is covered with a sequence of fine-grained sediments and peat. Based on the analysis of samples from a nearby core that shows a comparable sequence (Vos and De Vries 2007), this part of the column is most probably of Early Holocene age (Preboreal to earliest Atlantic), which is corroborated by a number of AMS dates. Later Holocene marine deposits are found on top of this sequence.

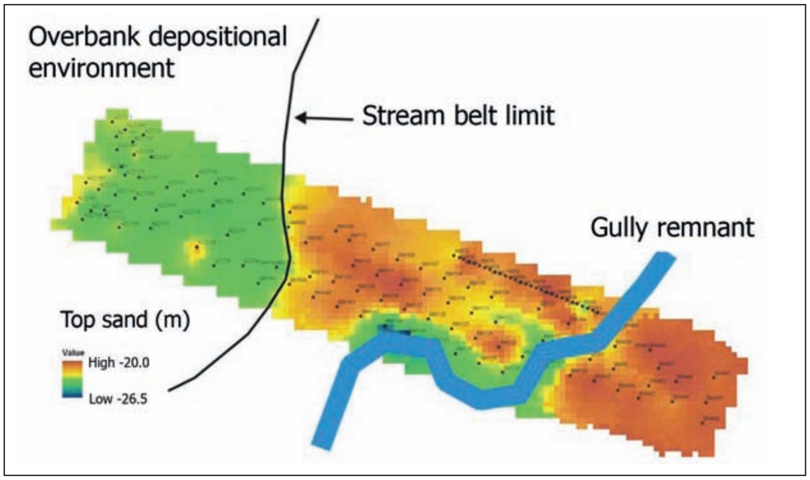

Figure 5.4: Spatial model of the Early Holocene topography (top of Pleistocene sand) in the Rotterdam Maasvlakte II harbour extension. The model is based on the lithological interpretations of more than one hundred cone probe readings, coupled with a small number of core descriptions (After Vos et al. *2009, with permission)*

The palynological and diatom data from the analyzed core suggest a gradual transition from a fresh to brackish water environment (Vos *et al*., in press). Hence, at this stage of research it appears that an intact Late Glacial to early Atlantic lithostratigraphic sequence is preserved in the study area. From a geogenetic perspective, this sequence is also consistent with the general model of environmental change for this part of the coastal zone (Hijma 2009). Considering the particular sedimentary characteristics and the spatial architecture of the subsequent deposits, the data suggest a full riverine Late Glacial environment, which gradually developed into a Holocene low-energy fluvial system that subsequently came under tidal influence. The geomorphology comprises a network of gullies, levees, and backlands (Fig. 5.4).

Pending the results of the analysis of new seismic data and core samples, the preliminary data are very promising. The lithostratigraphy comprises the time window that is archaeologically significant in relation to the barbed points collected over the past three decades. Also, the environments represented could have been highly attractive for hunting (particularly of aquatic mammals) and fishing activities. Whether this explains why such an astonishing number of barbed points are present in a relatively restricted area is another question (cf. Conneller and Schadla-Hall 2003, for alternative interpretations). For the time being, however, it is more important to recognize that the results do allow for the development of relatively detailed spatial models reflecting our archaeological expectations.

Hypotheses of the nature and distribution of archaeological phenomena can now be formulated and sampling strategies can be designed. The first rough model of palaeolandsurfaces and geomorphology provides some guidance. Evidently, there are some variations in the relief of the Pleistocene sand surface and several relatively prominent elevations occur alongside a gully. These elevations may have been attractive for temporary dwellings and are the most likely zones to contain significant evidence of human occupation. The gully itself can be expected to contain fish weirs, especially from the phase when tides began to influence the ecosystem.

As for the precise approach to sampling, several options have been put forward and will be decided upon once a detailed model of the subsurface is available. A restricted number

of undisturbed 'container-size' mega-samples could be taken in areas that potentially contain relatively high densities of materials. However, this poses technical problems while at the same time carrying the risk of 'missing the target'. Another possibility is systematic grab sampling, which does not have to be restricted to areas of high potential (in terms of find density). This approach, however, has the disadvantage of collecting disturbed samples. In order to deliver the desired contextual information, the possibility of linking lithological/lithostratigraphical information to sample location and depth is crucial.

Pleistocene mammals and the North Sea Neanderthal

The Eurogeul off Rotterdam harbour has produced vast amounts of palaeontological and, to a lesser extent, archaeological material (Glimmerveen *et al.* 2004, 2006; Mol *et al.* 2006). Targeted 'fishing' expeditions permitted the collection of well-preserved bones of a wide range of Pleistocene and Holocene animals that once lived in a myriad of environmental conditions. However, these are mixed assemblages. While some distinction in terms of age can be made based on fossilization/mineralization, this is far from reliable, and little can de said about the inter- and intra-population relationships.

In the context of the above-mentioned land reclamation activities of Maasvlakte II, huge volumes of sand are now being extracted from an area just south of the Eurogeul. Sand extraction reaches a depth of *c.* 40 m below Dutch OD, and hence includes a major part of the Pleistocene sequence. Based on the results of the 'bone fishing' activities, an important level is found at a depth of *c.* 26 m below Dutch OD and is known as the 'carcass horizon' among palaeontologists, owing to the impressive numbers of mammoth bones (including complete skulls). As in the case of the Maasvlakte–Europoort barbed points the sand extraction activities allow research to focus, for the first time, on the collection of contextual information of this material. Hitherto, Pleistocene mammalian remains, in the absence of direct evidence for human activity (e.g. cut-marks or association with stone tools), belonged to the domain of palaeontology, thus excluding them from legislative regulations. However, in the context of the Rotterdam harbour extension, the approach to prehistoric archaeology adopts

Figure 5.5: Mammoth-sized dredgers at work in the Eurogeul area off Rotterdam (Courtesy of Klaas Post)

a broader landscape-oriented perspective, where relationships between landscape dynamics and human behaviour form the central axis of research. This begs an understanding of landscape dynamics at different timescales, with or without direct evidence of human activity.

The strategy to tackle problems of the collection of contextual information at Rotterdam harbour is somewhat different compared to Maasvlakte–Europoort. The massive scale and rate of sand extraction hardly permits any fine-grained sampling of materials in context (Fig. 5.5). However, as sediment is extracted layer by layer, there is the possibility of collecting materials and positional information as work proceeds. In the current setup, bones and other items that remain stuck in the dredger mouths are kept aside and positional information is registered. Areas that are brought to the level of the 'carcass horizon' are next inspected for materials by means of beam trawling. The general stratigraphy is provided by vibrocoring. It is hoped that the totality of the data gathered will enable further inferences to be drawn about the context, and thereby increase the integrity of the bone assemblages, which in turn would add to their scientific value.

A comparable situation applies to the recovery of a Neanderthal cranial fragment from the so-called 'Zeeland Ridges', off the Zeeland coast. It currently constitutes one of the most northerly fossils of *Homo neanderthalensis* from Northwest Europe (Hublin *et al.* 2009). The fragment is a part of a frontal bone and was collected on the reject piles of a wharf in Flushing, where shells are sorted for industrial purposes. The bone fragment was found in 2001 but was only recognized as probably belonging to a Neanderthal in 2006. Thus its precise origin is unknown, although a reasonable approximation can be made. While the sample did not contain sufficient collagen for ^{14}C dating, it is believed to represent a relatively late

Figure 5.6: The Zeeland Ridges Neanderthal frontal bone interior (left) and exterior (right) views. Scale in centimetres (Photo: Erik de Goederen, reproduced with permission of the National Museum of Antiquities, Leiden)

Neanderthal comparable in age to the remains from La Chapelle-aux-Saints in southwest France (Fig. 5.6). The same general 'location' has produced several Middle Palaeolithic handaxes (Verhart 2004), which may be contemporaneous with the Neanderthal find.

Again, an initiative has been taken to clarify the context of these finds. This research is being conducted by a group of geologists, palaeontologists, and archaeologists from the universities of Leiden and Utrecht, as well as Deltares/TNO Geological Survey of The Netherlands. The main aim is to develop predictive scenarios based on an integration of all existing data and insights regarding the Pleistocene geological evolution of the Dutch part of the North Sea between Hoek van Holland and the Belgian border (Marc Hijma, pers. comm.). This pilot study involves a desk-based assessment, which will be used largely as a framework for future research, including offshore sampling.

Approaches to heritage management

Traditionally, heritage management approaches in The Netherlands have been focused on 'sites' as spatially constrained occurrences of archaeological material. This perspective is essentially rooted in the particular reference to 'anthropogenically fashioned' items in the Monuments Act, as well as in the traditional over-emphasis on the later prehistoric to Medieval periods in Dutch archaeology (Rensink *et al.* 2006). It was not until recently that explicit attention was drawn to the necessity to broaden the scope and consider the value of archaeological phenomena in a wider (palaeo)environmental setting, insofar as it concerns the archaeology of hunter-gatherers (Peeters *et al.* 2002; Rensink and Peeters 2006; Peeters 2007). There is growing awareness that palaeoenvironmental archives should be considered as an inextricable aspect of the early prehistoric heritage and, indeed, the aforementioned initiatives illustrate this conceptual shift.

Significantly, the importance of the North Sea (including the Dutch part of the continental shelf) is now fully acknowledged in the recently published *North Sea Prehistory Research and Management Framework (NSPRMF) 2009* (Peeters *et al.* 2009) (Fig. 5.7). As the outcome of a shared concern among researchers and heritage professionals from the United Kingdom and The Netherlands, it outlines the scientific importance of the area for understanding long-term processes of landscape evolution, climate change, and human adaptations, and sets an agenda for research and management priorities for the next five years. Fifteen academic institutions and heritage organizations from The Netherlands, United Kingdom, and Belgium are currently supporting the NSPRMF.

Among the biggest challenges for the near future is the development of tools that will enable academia and heritage professionals to face major changes in the economic exploitation of the North Sea. In order to anticipate and assess the potential impact of threats, there is an urgent need for maps and models that express research potentials based on up-to-date geological, archaeological, and palaeontological insights. At the same time, such maps can be used for steering research programmes on a less *ad hoc* basis.

However, it should be conceded that the number of good data points is, at present,

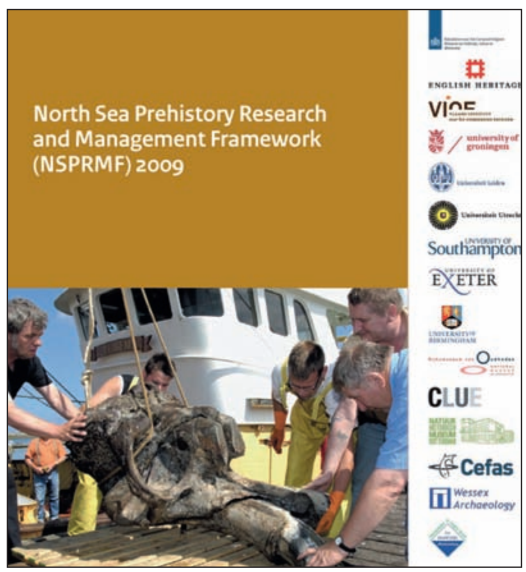

Figure 5.7: The NSPRMF is designed "… to facilitate the large-scale systematic and interdisciplinary study and preservation (where possible) of a unique sedimentary and archaeological record of some two million years that is currently submerged beneath the waters of the southern North Sea. This is intended as a 'living document' and so further comments from colleagues will be noted, and incorporated into future versions" (Peeters et al. *2009: 7)*

insufficient to produce a reliable model for further research offshore (Fig. 5.8). From this perspective, it is essential to continue and collect more data, even if this leads to (partial) destruction of sites. The methods (beam trawling) of the Dutch fishing fleet that have resulted in the discovery of large amounts of material may affect the preservation of 'sites' at or close to the seafloor, but when used as a controlled sampling technique valuable information can be gathered. Combined with geological data and subsequent underwater inspections and targeted sampling strategies, the quality of data can be increased substantially. The 'Mesolithic zone' identified in the Brown Bank area may indeed provide an interesting test case for such an approach, and possibilities are currently being considered.

As mentioned above, there is growing concern in Dutch heritage management about the investigation and preservation of submerged prehistoric sites and landscapes. As the Malta Act also applies to the marine environment, we are now witnessing a change of attitude. With the rapidly expanding economic exploitation of the North Sea, this comes not a moment too soon. However, the current state of knowledge – notwithstanding its steady increase – among scientists and heritage professionals lags behind the rate of economic exploitation and subsequent disturbance of the seabed. The same holds true for the limited number of qualified people with ample experience in this field. Hence, there is need for action to redress the balance. International cooperation and exchange of expertise is crucial in this respect, as well as funding for training, and the creation of employment opportunities for students (cf. Bailey, this volume).

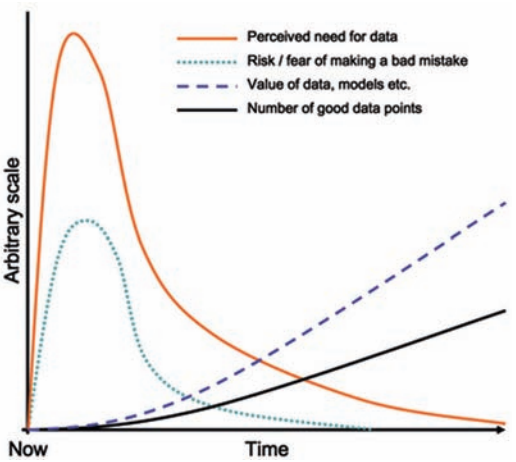

Figure 5.8: Schematic representation of the relationship between scientific knowledge and decision-making (Peeters et al. *2009)*

Conclusions

This chapter has presented a brief account of the current state of affairs in the Dutch approach to submerged prehistoric sites and landscapes. In particular, the spectacular results relating to the activities of the fishing fleet have triggered a number of initiatives over the past few years that have added to a growing awareness of the potential and importance of the North Sea for prehistoric archaeology and palaeoenvironmental studies. The particular value lies precisely in the relationship between the two fields of research. This situation is recognized by heritage professionals and has led to the adoption of strategies that allow for more integrated approaches to research and management, although we have to be mindful that expertise is still very sparse and we find ourselves in a rather experimental phase. An integrated approach to archaeological and palaeoenvironmental research is consonant with current approaches in Dutch wetland archaeology. Hence, a shift of attention toward the North Sea, as an extension of our wetland environments, is entirely logical. And this, indeed, is as wet as it can get.

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6

Seabed Prehistory: investigating palaeolandsurfaces with Palaeolithic remains from the southern North Sea

Louise Tizzard, Paul A. Baggaley and Antony J. Firth

Between December 2007 and February 2008, lithic artefacts, including handaxes, flakes, cores, and faunal remains were discovered in stockpiles of gravel at the SBV Flushing Wharf, near Antwerp, Belgium. The artefacts were recovered from a discrete locale within Area 240; a marine aggregate licence area situated approximately 11 km off Great Yarmouth on the coast of Norfolk, England. The discovery has shown that archaeological material of great significance can be present in deposits targeted for marine aggregate extraction. However, archaeologists have only limited capacity to identify and localize such deposits in the marine environment. This chapter presents the latest results of an ongoing project that uses geophysical, geotechnical, and seabed sampling methodologies to provide data on the context of the handaxes and other material recovered from Area 240.

Keywords: North Sea, prehistory, Palaeolithic, stone artefacts, Pleistocene fauna

Introduction

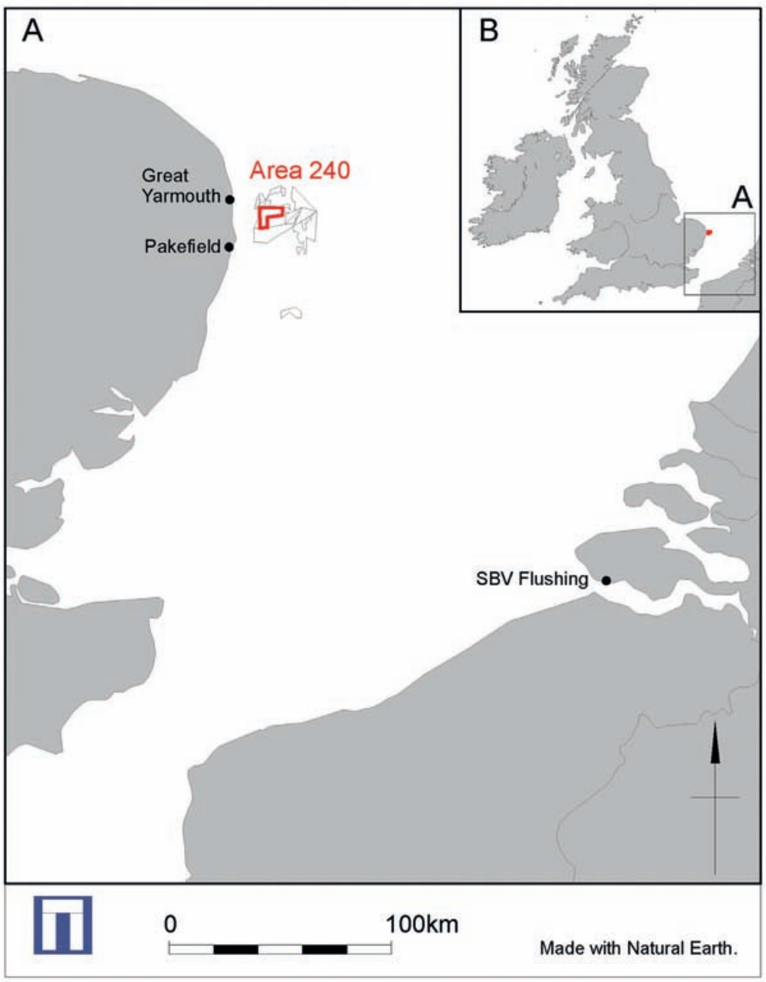
The Quaternary (Pleistocene and Holocene) has been a period of fluctuating climate with corresponding oscillations in sea level (Bridgland 2002). During interglacial periods sea levels were relatively high, sometimes comparable to the present day, whereas at the climax of glacial periods the sea levels fell to more than 100 m below present levels. During these multiple cycles of transgressions and regressions various areas of the southern North Sea have been repeatedly exposed. For a large proportion of the Middle and Late Pleistocene, rivers extended beyond present-day shorelines onto the continental shelf. These extensions of existing rivers, enlarged by confluences that are now submerged, and swollen by glacial meltwater, would have been drainage systems of considerable size (Bridgland 2002).

Stone artefacts have long been found in sediments associated with river channels, either in sand and gravel layers or associated fine-grained sediments and peats (e.g. Wymer 1999). The presence and survival of these artefacts are closely linked to the environmental processes that caused the associated deposits to be formed. Terrestrial archaeological finds have been documented along the course of the River Yare (Wymer 1999). These refer to single, isolated finds along the valley and comprise mainly handaxes and stone flakes. These finds are considered to be Lower Palaeolithic and are predominantly found in reworked fluvial or glacial sediments, rather than in an *in situ* context (Wymer 1985). To the south of Great Yarmouth, at Pakefield, a number of artefacts, and well-preserved faunal and plant remains have been recovered (Stuart and Lister 2001; Parfitt *et al.* 2005). The Pakefield site lies on the course of the Bytham River, a pre-Anglian river that drained across central Britain into the North Sea, which has produced a series of Lower Palaeolithic sites along its length. Numerous artefacts have been recovered since 2000 at the

Pakefield site. The material suggests that flint knapping was undertaken at the site and that the raw material source was probably collected locally from the banks of the channel (Parfitt 2008). At Happisburgh Site 1 on the north Norfolk coast, a lithic assemblage was collected from organic muds on the foreshore and is considered to have been in a primary context (Ashton *et al.* 2008). Recent discoveries at Happisburgh Site 3 include an assemblage of 78 flint artefacts (cores, flakes, and tools) excavated from fluvial and estuarine sediments (Parfitt *et al.* 2010).

The recovery of Palaeolithic stone artefacts and Pleistocene faunal remains from the southern North Sea has a long history predominantly associated with the fishing industry and, more recently, the dredging industry (Godwin and Godwin 1933; Glimmerveen *et al.* 2004; Mol *et al.* 2006). Numerous mammal remains have been reported from a relatively restricted area in the southern North Sea between the Brown Bank area and the Norfolk coast, which have yielded Early and Middle Pleistocene mammal fossils (van Kolfschoton and Laban 1995; De Wilde 2006). Isolated finds of artefacts such as flints, bone spearheads, and reworked or carved fossil mammal bones are also documented (Long *et al.* 1986; Coles 1998; Flemming 2002) and a number of finds and faunal remains have been, and continue to be, reported from aggregate dredging areas via the marine aggregate industry protocol for reporting finds of archaeological interest (BMAPA and English Heritage 2005).

Figure 6.1: Location map



Between December 2007 and February 2008, 75 Palaeolithic artefacts, including handaxes, flakes, and cores, and a number of bones (including woolly mammoth, bison, horse, and reindeer) were discovered by Mr Jan Meulmeester in stockpiles of gravel at the SBV Flushing Wharf (Fig. 6.1). Based on the dates of these finds and through consultation with Hanson Aggregates Marine Limited (HAML) it was established that the artefacts and faunal remains were dredged from a discrete locale within marine aggregate licence Area 240, and their provenance is judged to be secure (Fig. 6.2). Initial inspection of the artefacts indicated that they were sourced from three environments: those found in a primary context, those originating from an eroding surface, and those derived from the seafloor (Hans Peeters, pers. comm. 2008). This indicates a complex, rather than simple, find site and suggests the dredger impacted a range of deposits containing artefacts, rather than one single deposit. The lithics are currently being assessed by Dr Dimitri de Loecker at the University of Leiden and the faunal remains by Dr Jan Glimmerveen.

Area 240

Area 240 is situated approximately 11 km off the coast in water depths of between -16.7 and -33.5 m CD (18.2 and 35.0 m below OD). Tidal currents in the southern North Sea are locally strong, averaging 0.5 m s^{-1} and up to 2 m s^{-1} (Admiralty Chart no. 1543, Winterton Ness to Orford Ness) and the area is dominated by a series of west to east orientated sandwaves, up to 6 m high. Although locally strong, it is unlikely that the currents are strong enough to move the flint artefacts. The area where the handaxes were dredged is a discrete 3.5 × 1.1 km area in water depths of -20 to -33.5 m CD (21.5 and 35 m below OD) and is situated within an active dredging area although, since the discovery, a

voluntary exclusion zone has been in place by HAML (Fig. 6.2).

Methodology

Although a number of apparently isolated artefacts, without stratigraphic context, have been retrieved in the North Sea through fishing and dredging activities, there are relatively few examples of known submerged Palaeolithic and Mesolithic sites. Known prehistoric sites survive in protected low-energy environments along coastlines (Flemming 2004) and are usually accessible for diving investigation. For example, in Danish waters diving investigations have proved successful in locating Palaeolithic and Mesolithic sites in water depths less than 20 m (cf. Andersen, this volume; Uldum, this volume; Fischer, this volume). These sites were investigated primarily by divers, although heavier equipment such as industrial sand-pump dredgers and hydraulic digging machines were also employed (Fischer 2004). Archaeological investigation by divers in the western Solent, England, led to the discovery of Mesolithic occupation sites in water depths less than 20 m (Momber 2004, this volume).

The site under investigation in Area 240 is not conducive to diving methodologies; water depths approaching 30 m mean that diving time would be limited using standard air (or would require mixed-gas/technical diving to work effectively at such depths). The strong currents in the area would mean that diving could only be conducted at slack water, further limiting time availability. Also, the visibility is notoriously poor in the area, which would further hinder diving operations. As a result, the prospect of locating flints, particularly in an area of 3 km^2 without a more precise location for the find spot is remote and would require a major commitment of time and money. Cost effectiveness would be low and the chance of failure to find artefacts would be high. Although the areas where the artefacts were found is relatively discrete, the size of the area and the environmental conditions favour the development of a project combining geophysical, geotechnical, and seabed sampling techniques.

The project has been divided into a series of stages allowing the work to be developed on an iterative, judgement-led basis. Stage 1 involved the review of an existing geophysics dataset that was acquired in 2005 for the assessment of aggregate reserves across the whole of Area 240, and the review of 158 vibrocore logs acquired between 1999 and 2007.

Geophysics data reviewed included multibeam bathymetry and sub-bottom profiler (boomer source) data. The data were acquired at 100 m line spacing (north–south main lines) and cross lines at 1 km line spacing. Approximately 420 line km sub-bottom profiler data were reviewed. The review provided a wider context for the subsequent detailed geophysical investigations of the handaxe site (Stage 2), ensuring that the localized investigations took place in the knowledge of their broader context.

Stage 2 was concerned with the acquisition, processing, and interpretation of geophysical data from the 3.5 × 1.1 km site within Area 240 where the handaxes were discovered (Fig. 6.2). The geophysical survey was undertaken in April and May 2009 and comprised the acquisition of side-scan sonar, magnetic, single-beam echo sounder, and sub-bottom profiler datasets (boomer, pinger, parametric sonar, and chirp). Data were acquired at 20 m line spacing, resulting in a higher resolution dataset than that acquired in 2005; approximately 270 line km sub-bottom profiler data were acquired. The use of multiple sub-bottom profiler sources enabled methodological comparisons between the different sources. The geophysical data from the 2005 and 2009 datasets, together with the available vibrocore data, were integrated to achieve an overall interpretation of the 3.5 × 1.1 km area within the context of Area 240 as a whole. Based on this interpretation, a series of transects was proposed for sampling the sediment units considered likely to contain flint artefacts and faunal remains.

Submerged features

The results of Stages 1 and 2 reveal a complex history of deposition and erosion in Area 240, the interpretation of which has been further complicated by dredging operations over the last 20 years.

A series of sediment units dating from the time of the earliest occupation of Britain – arguably as early as *c.* 936,000 BP (Parfitt *et al.* 2010) – to the last marine transgression, *c.* 7200 BP/6100 cal BC (Behre 2007) was interpreted, although not as a complete sequence. Two channel features, Channel A and Channel B, dominate the area (Fig. 6.2). Channel A is observed to the north of where the artefacts were

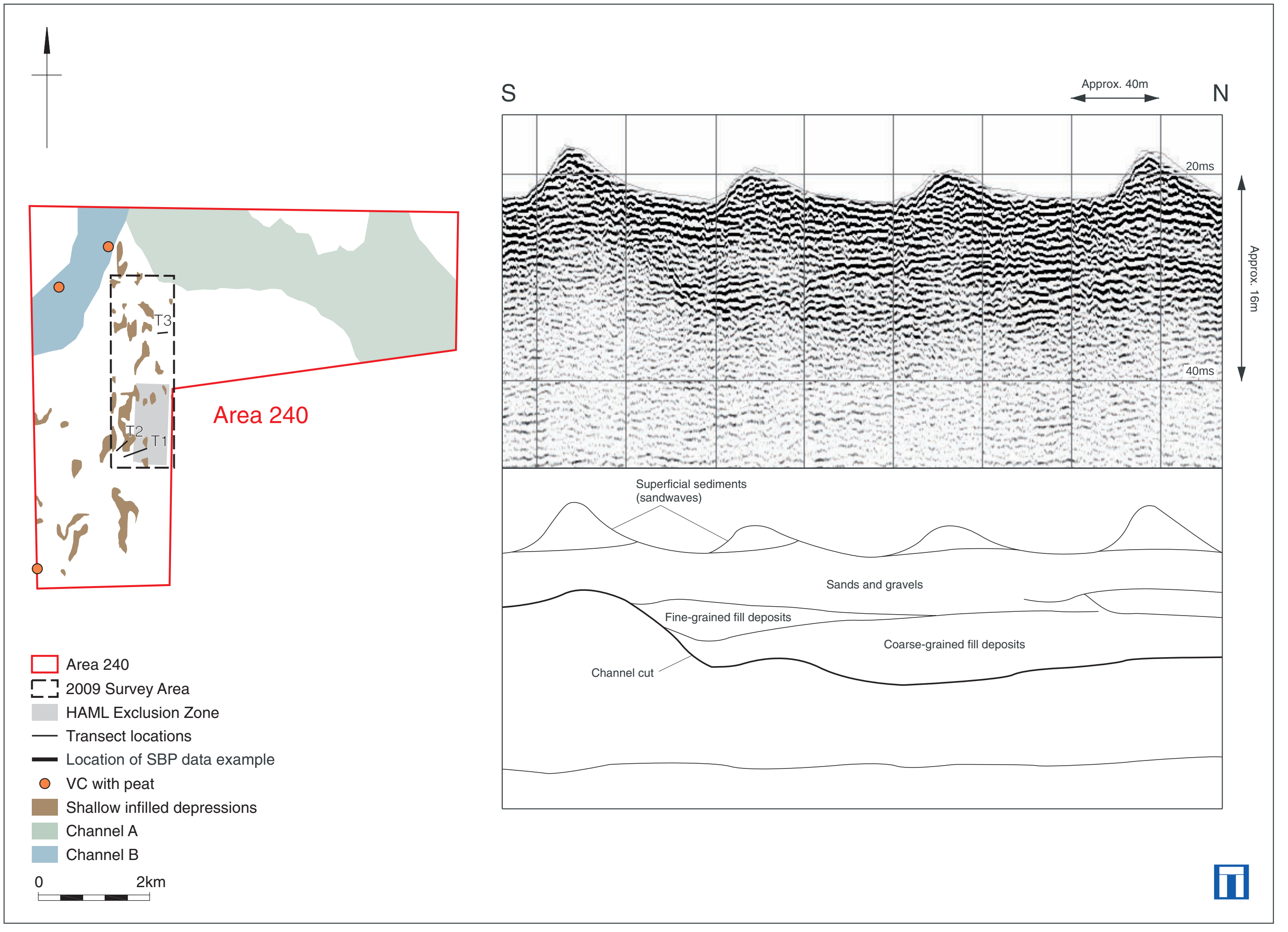


Figure 6.2: Area of dredged artefacts and exclusion zone; submerged features interpreted from the geophysics and geotechnical data; interpreted sub-bottom profiler (boomer) profile illustrating the cut and infilled nature of Channel A

dredged, orientated northwest to southeast. The southern edge of the channel is prominent and is observed as a 5 m deep cut (Fig. 6.2). The northern edge is less obvious and is observed as gently shoaling, rather than being a steep cut. The sediment infilling this buried channel varied in composition and is indicative of a changing flow regime with periods of high-energy and low-energy sediment deposition. The high-energy depositional sediments comprise sands and gravels and are observed on the sub-bottom profiler as units of strong reflectors. Fine-grained sediment units, indicative of lower-energy depositional environments, are observed as seismically transparent units (Fig. 6.2) and are observed infilling broad shallow depressions or forming small bank structures up to 3 m high. The vibrocore data indicate that this unit comprises clay with occasional shells overlain by a thin unit of clayey sand. There is also some evidence of oxidation, which may be a result of weathering and exposure to oxygen and the formation of a gley type soil.

The floodplain of Channel A is extensive, encompassing the majority of Area 240 and comprising sands and gravels. The age of the channel cut-and-fill deposits is, at present, unknown, but the channel may have been cut as early as the Late Anglian Glacial (*c.* 430,000 BP). Studies carried out to the north of the survey Area 240 (Wessex Archaeology 2008) indicate that the coarse-grained fill may have been deposited during the Wolstonian Glaciation (*c.* 300,000–130,000 BP) with the finer-grained sediments deposited at the onset of the Ipswichian Interglacial (*c.* 130,000–110,000 BP). However, further research is needed to confirm these dates.

Channel B is shallow and meandering, is situated in the northwestern corner of the survey area, and is orientated northeast to southwest (Fig. 6.2). Channel-fill deposits are

observed on the sub-bottom profiler data and a topographic trace of the channel is also observed on the bathymetric data. The topographic trace indicates a broad feature, approximately 1 km wide and up to 4 m high. Sub-bottom profiler data indicate that the infill sediments are up to 6.5 m thick and the vibrocore data indicate a fill sequence including peats and other organic sediments, which are indicative of low-energy deposition in a fluvial or marshland environment. Independent dating of four peat samples from a vibrocore situated within Channel B deposits dates the peat between 10,140±35 BP (10,040–9660 cal BC, SUERC-11978) and 8355±35 BP (7530–7330 cal BC, SUERC-11975) (Hazell, pers. comm. 2010). Based on the Early Mesolithic date of these sediments, Channel B may be an offshore extension of the River Yare and the peats may be comparable to those of the Breydon Formation (Arthurton *et al.* 1994; Bellamy 1998). Onshore, the basal peat of the Breydon Formation has been dated to *c*. 7580±90 BP and is observed at 19 m below OD. Around 6 km offshore Great Yarmouth clays of the Breydon Formation are observed at a depth of 27 m below OD. These are comparable depths to the Early Mesolithic peats and clays between 30–32 m below OD in Channel B. The basal peat of the Breydon Formation is overlain by the Lower Clay composed of soft silty clay which becomes firmer with depth (Arthurton *et al.* 1994), and which may be comparable with the thin unit of sandy, shelly clay observed overlying the peats in the vibrocores from Channel B.

Further features observed in Area 240 in Stages 1 and 2 include slight depressions cutting into the floodplain deposits. These depressions are predominantly situated in the central and southern areas and are infilled with finer-grained deposits (clays and fine-grained sands) and suggest an outer estuarine or near coastal depositional environment. The relative chronology of these deposits to the Early Mesolithic peats is unknown as there are no areas where these units coincide to provide any direct stratigraphic relationship. The Early Mesolithic peats and clays in Channel B and those older sediments deposited in Channel A highlight the preservation of sediments deposited prior to the last marine transgression, which here occurred around 7200 BP/6100 cal BC (Behre 2007). In the area where the artefacts were dredged in 2007/2008, the upper sediments primarily comprise sands and gravels associated with the southern floodplain of Channel A, and depressions infilled with outer estuarine sediments (Fig. 6.2).

Sampling for artefacts

Stage 3 was developed on the basis of the results of Stages 1 and 2. The aim of Stage 3 was to assess the capability of seabed sampling methodologies to enable observations of prehistoric artefacts, palaeoenvironmental material, and their spatial distributions. The survey was conducted in July 2009 trialling three methods and equipment types: clamshell grabs, video survey, and scientific beam trawl. Samples were acquired along three transects selected on the basis of the geophysical interpretation (Fig. 6.2).

In practice, the video survey proved unsuccessful due to the environmental conditions and poor visibility. Instead, a drop-down high visibility camera was substituted to acquire a series of still photographs at five locations at equal intervals along each transect. The photographs were used to assess the seabed conditions along the length of each transect. A 2 m scientific beam trawl with chains and a 5 mm cod-end mesh was towed along the length of each transect. Finally, a series of clamshell grab samples was acquired using a 280 litre capacity grab. The positions and numbers of samples acquired along each transect varied, depending on the initial photographic results and iterative results of the grab samples. Positional data were provided using dGPS and a USBL acoustic tracking system.

In total, 48 grab samples were acquired recovering approximately 8250 litres of sediment (*c.* 16.7 tonnes). The samples were initially processed for artefacts on board the vessel, as follows: on recovery, the samples were visually inspected and any significant material removed and bagged, a 40 litre sub-sample was taken for further post-survey analysis, and the remaining sediment was wet-sieved through a 10 mm sieve and inspected for artefacts.

Post-survey, the 40 litre sub-samples were wet-sieved through a nest of (10 mm, 4 mm, and 1 mm) sieves in accordance with standard artefactual recovery procedures. The residues were scanned for archaeological material.

The low-visibility drop-down camera produced a series of good quality images that provided detail on the seabed sediments and were used to select the initial grab sample

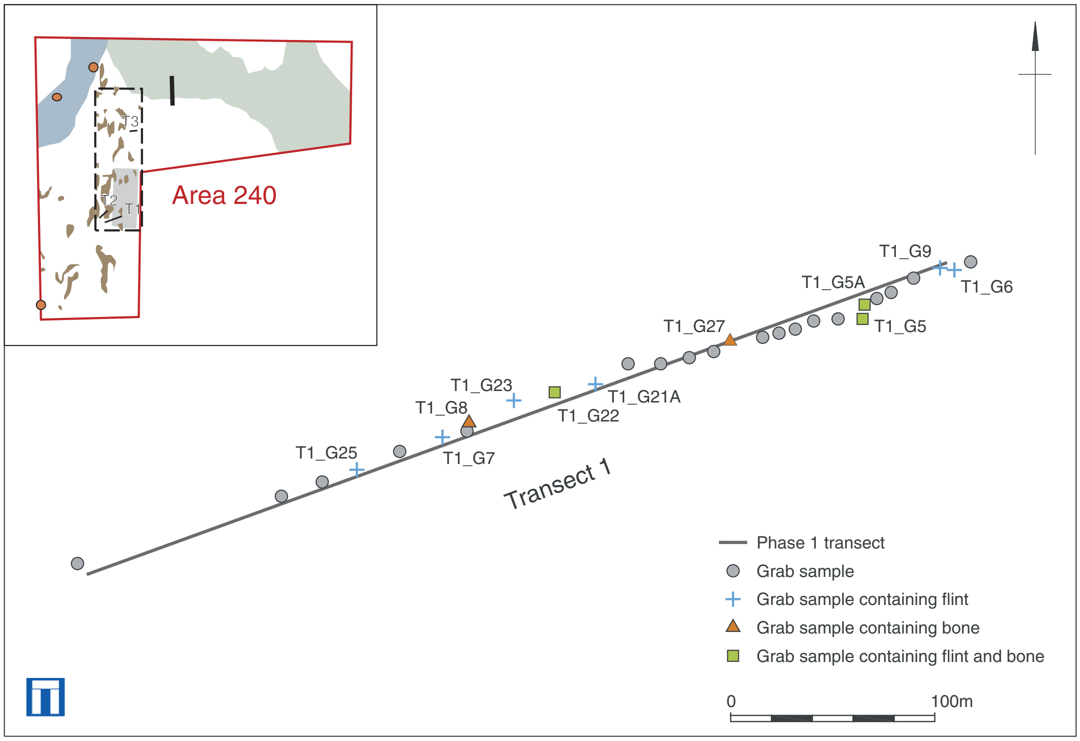


Figure 6.3: Clamshell grab sample stations along Transect 1 and locations of flint and bone recovered from the clamshell grab samples

locations. At each transect seabed sediments were dominated by sands and gravels, with occasional cobbles and rolled surficial peat. Similarly, the beam-trawl samples recovered gravel, rolled peat, and waterlogged wood, as well as seabed fauna. No flint artefacts were recovered using this methodology, although the rolled peat and waterlogged wood indicated the presence of former terrestrial land surfaces in the vicinity. The clamshell grab generally recovered in excess of 150 litres of sediment per sample. The sediments predominantly comprised sands and gravels, as expected.

The still photographs, samples from the beam-trawl survey, and initial grab samples all suggested that Transect 1 had the most potential and as such more clamshell grab samples were acquired along the transect (Fig. 6.3) to close the gaps between the initial sample stations. A total of 31 samples were acquired along Transect 1.

In total, 15 flint flakes and 10 pieces of bone were recovered from the clamshell grab samples. The recovered flint consisted entirely of flint flakes, the by-products of flint tool manufacture. Although it can be difficult to distinguish humanly produced flint flakes from those that occur naturally, of the 15 flakes recovered all are of probable anthropogenic origin, but eight are more obviously genuine artefacts. These eight flakes were recovered from Transect 1 (Fig. 6.3). Detailed descriptions of the sediments and flakes are given in Table 6.1.

Two of the flakes, from T1_G22 (Fig. 6.4) and T1_G25, are broken mid-sections of tertiary flakes with well-defined flake scars and are characteristic of handaxe thinning flakes found at other sites. The flake from T1_G23

Figure 6.4: Flake recovered from clamshell grab sample T1_G22 identified as a broken mid-section of a tertiary flake with well-defined flake scars

Table 6.1 (opposite page): Sediment and lithic flake descriptions for Transect 1.

Grab station	Sediment description	Flint (recovered offshore)	Flint (sub-sample)	Flake description
G5	10YR 6/2 Light brownish grey gravelly sand. Sand is fine to medium grained. Occasional sub-rounded quartz and quartzite up to 40 mm diameter. Occasional FeO concreted mudstone up to 50 mm diameter.	x		A very thin flake in mint condition and unstained. The point of percussion is located at the edge of the flake. It is possible that this flake was removed by natural processes, however there are apparent traces of platform preparation and other facets suggest that this is a product of debitage.
G5a	10YR 4/2 Dark greyish brown sand. Sand is medium grained. Moderate broken shell. Gravel is predominantly flint, sub-rounded to sub-angular up to 100 mm diameter. 5% Quartz, rounded to sub-rounded up to 30 mm diameter. Occasional brown sandstone (up to 4 mm diameter). Occasional FeO mudstone lumps up to 150 mm diameter.		x	A heavily rolled flake with a glossy finish. It is naturally backed. The proximal end is missing, having been chipped by recent damage; however the presence of clear conchoidal rings on the ventral surface and similar well defined traces on the dorsal surface, indicating a previous removal, suggest that this flake is genuine.
G6	10YR 4/3 Brown sand. Sand is fine to medium grained. Occasional quartz sub-rounded up to 30 mm diameter. Very occasional rose quartz. Occasional rounded to angular flint up to 70 mm diameter.	x		This is a primary flake that is both patinated and stained. It is hard hammer struck. The striking platform is plain and the point of percussion is well positioned on the striking platform and not a glancing blow.
G7	10YR 5/4 Yellowish brown gravelly sand. Flint up to 110 mm diameter rounded to angular (predominantly angular). Occasional quartz and quartzite up to 43 mm diameter. Occasional broken shell.	x		A small patinated and rolled primary flake, open to some doubt as to its formation
G9	10YR 5/3 Pale brown sand. Sand is medium to coarse grained. Frequent small, sub-rounded to sub-angular up to 60 mm diameter. Occasional quartz up to 22 mm diameter.	x		Clearly hard hammer struck and is part of a 'compound' removal, where another flake was removed at the same time, by the same blow. While not certain, it is possibly the result of human workmanship.
G21a	10YR 6/3 Pale brown sand. Sand is medium to coarse (predominantly coarse) grained. Frequent small to medium up to 80 mm diameter rounded to angular flint. Very occasional quartz up to 35 mm diameter. Occasional ?limestone up to 45 mm diameter. Two ?metamorphic pebbles. Moderate broken shell up to 3 mm diameter.	x		This is an elongated hard hammer struck flake. It is unstained and unpatinated. The presence of other flake scars suggests that it is the product of deliberate, systematic debitage.
G22	10YR 7/3 Very pale brown fine, medium and coarse (predominantly coarse) grained sand. Occasional small flint rounded to angular up to 90 mm diameter. Occasional small broken molluscs. Occasional FeO mud concretions.	x		This is a mid section of a tertiary flake, with well-defined conchoidal rings on the ventral surface. The dorsal surface also has a number of converging negative flake scars. It has a slightly dipping profile. These features, including the way in which it has broken, have been noted on other handaxe thinning flakes.

Continued over the page

Grab station	Sediment description	Flint (recovered offshore)	Flint (sub-sample)	Flake description
T1_G23	2.5Y 4/1 Dark grey silty sand mottled light grey. Sand is coarse. 4% black ?degraded organic stain mottling. Occasional small to medium rounded to angular flint to 75 mm diameter. Occasional broken molluscs including *Ostrea edulis*. Occasional sub-rounded quartzite up to 70 mm diameter. One rounded granite pebble 10 mm diameter. One brown conglomerate 40 x 4 mm.	x		This is a stained and patinated primary, hard hammer struck flake. The most convincing feature that indicates human production is the clear striking platform and well positioned point of percussion well back from the edge of the core.
T1_G25	10YR 5/4 Yellowish brown gravelly sand. Gravel is predominantly flint, rounded to angular up to 100 mm diameter. Occasional quartzite up to 25 mm diameter. Occasional quartz up to 15 mm diameter.	x		Flake is similar to that from sample T1_G22. This flake also lacks the proximal and distal ends, so valuable details of the technology are lost. However, the dorsal surface has a number of residual flake scars, which form a radial pattern.

is a primary flake of clear anthropogenic origin with a striking platform and point of percussion (Fig. 6.5) and the flake from T1_G5 shows evidence of platform preparation. The flakes from T1_G5a and T1_G21a show evidence of deliberate, systematic debitage. Two flakes, from T1_G6 and T1 G9, are hard hammer struck and although less convincing than the other flint flakes, are probably of human workmanship. The remaining five flint flakes from Transect 1 (G7, G9, G25 [three pieces]) and two from Transect 2 are considered possible artefacts but open to doubt and may have been formed by natural processes.

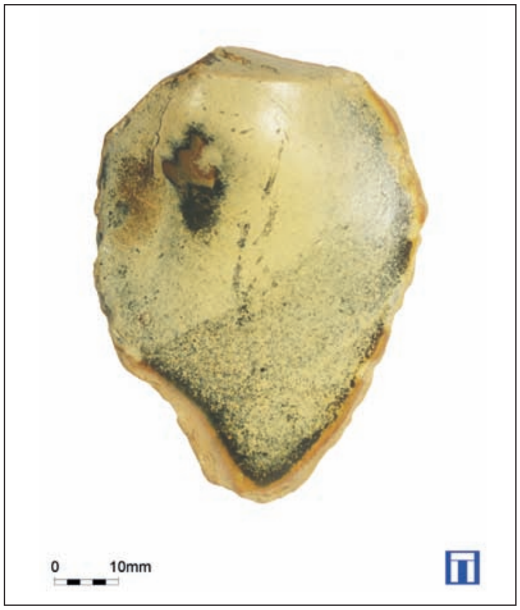


Figure 6.5: Flake recovered from clamshell grab sample T1_G23 identified as a primary flake of clearly anthropogenic origin with a striking platform and point of percussion

Ten pieces of bone were recovered from the clamshell grab samples: nine from Transect 1 (Fig. 6.3) and one from Transect 3. Most of the pieces recovered are unidentifiable. Two pieces of fossilized bone were recovered from T1_G5, one unidentifiable and one broken bovine or cervid centrotarsal. Two other pieces of unidentified fossilized bone were recovered from T1_G5a. A small piece of unidentifiable bone was recovered from the sample T1_G8 and two pieces of large, probably terrestrial mammal bone were recovered from T1_G27. A fish vertebra, probable salmonid, was recovered from T1_G22 and a vertebra from an aquatic mammal, probable dolphin, was recovered from Transect 3. The occurrence of terrestrial mammal bone in T1_G5 and T1_G27 from the northeastern end of the T1 (Fig. 6.3) is of interest given that Mr Meulmeesters original discovery included terrestrial mammal bone and the presence of rolled peat and waterlogged wood indicates a terrestrial landscape.

The flint flakes with the clearest diagnostic features and the faunal remains were mostly recovered from Transect 1 and are associated with the unit identified on the geophysics data as the sand and gravel unit forming the floodplain of Channel A, in close proximity to the unit identified as fine-grained outer estuary sediments.

Although a series of flakes and bones was

obtained by sampling in this area, no handaxes or evidence of a site were found. This is likely to be a reflection of the methodology employed rather than of the material present. Despite the choice of sampling location being judgement led and based on as much evidence as was available and the systematic, targeted approach using photographic stills and grab sampling, only a very small proportion of the area was sampled. The volume of sediment sampled using the clamshell grab was a fraction of the volume of cargo from Area 240 in which Mr Meulmeester made his discoveries. Assessing sites and sampling for artefacts at marine (*vs* coastal) sites is complex and challenging.

Conclusions and future work

The work conducted to date has confirmed the likely provenance of the assemblage discovered by Mr Meulmeester in 2007–2008. Moreover, the entire assemblage can now be related to particular deposits. These deposits form part of a broad context whose extents and sequences have been mapped from existing and new geophysics data. The finds identified during this project and those previously recovered indicate that the area is significant in terms of its artefact content, although there are still questions to be answered regarding the context, age, and depositional environment of sediments from which the artefacts were recovered.

During summer 2010, vibrocores were acquired at 10 locations within Area 240. The aim of the geotechnical survey was to target sediment units that should provide palaeo-environmental material allowing for the assessment, analysis, dating, and reconstruction of the landscape within Area 240, and in particular the area in which the handaxes and flint flakes have been recovered.

The results of this project should not only provide geological and environmental contexts for the Palaeolithic finds recovered to date, but also through demonstrating suitable methodologies, help to improve the future management of the potential effects of aggregate dredging on the marine historic environment.

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7

Experiencing Change on the Prehistoric Shores of Northsealand: an anthropological perspective on Early Holocene sea-level rise

Jim Leary

This chapter discusses how people and communities were affected by, and reacted to, sea-level rise in the Mesolithic period. It adopts a local-scale perspective to help understand the experience of the landscape changes associated with sea-level rise. It is argued that such an approach provides us with a greater understanding of the effects of these changes. The communities' vulnerability and resilience to these changes is also discussed and, combined with ethnographic examples, emphasizes the complex relationship between humans and their environment.

Keywords: Mesolithic, sea-level rise, experience, vulnerability, resilience

Introduction

Although uncertainties exist as to the speed and timing of Holocene sea-level rise, there have been, in recent times, significant advances in our understanding of the prehistoric landscape of the North Sea (Gaffney *et al.* 2007; Wessex Archaeology 2007). Largely based on seismic data, this literature concentrates on large swathes of the North Sea and English Channel, mapping the Holocene topography in some detail. These approaches are, by their nature, large-scale palaeoenvironmental studies and this can lead to little consideration of the human aspect of sea-level rise, the way people either perceived or reacted to sea-level rise and the associated loss of land and resources (but see Gaffney *et al.* 2009). Chapman and Lillie (2004) and Leary (2009) provide the only discussions with the contemporary perception of environmental change as the central theme (but see Fischer 1995; Pedersen *et al.* 1997). Chapman and Lillie (2004) adopted a micro-scale approach to model sea-level rise in Holderness, East Yorkshire, demonstrating that a continuous sea-level rise in this topographic setting resulted in little initial landscape change followed by rapid inundation.

Such a micro-scale approach is helpful since Holocene sea-level rise is normally addressed at a scale that does not allow for the local perspective to be considered. And yet it is on the local scale that these very changes would have been observed, and adaptations developed. Models for Holocene sea-level rise tend to describe it as a smooth, linear process, with curves worked out as an 'average'. This is a static approach that does not deal with the dynamism and uncertainties of sea-level rise. It does not consider the periods of rapid change and wild swings; the way the sea would have risen haphazardly in fits and starts as thresholds were crossed.

These changes unfolded on a local scale; they were perceived locally and formed part of everyday life. And although we now know sea-level rise to have been a global event with a long chronology, it would not have been understood as such in the Mesolithic; the changes would have been regarded as a local phenomenon and experienced within living time. Models that do not discuss the local scale miss out on both

the major effect and fine nuances of it, and are therefore limited. This is not to set up a dichotomy between the two different scales, for it is useful to have large-scale models to work to, but physical changes were appreciated at a local scale – on the ground so to speak. Discussions of past sea-level rise, and indeed climate change, need to bridge this analytical gap and combine large-scale models with local-scale studies and adopt a more humanized approach.

In many ways this difference between the large scale and local scale, is similar to that between modern climate change scientists and anthropologists. On the one hand scientists monitor global climate change through instruments (measuring, for example, temperature, rainfall, and atmospheric pressure), and from these produce large-scale models of change. While on the other hand anthropologists engage with 'traditional ecological knowledge' to help understand how the people living on the land (the local level) perceive their environment to have changed. Frequently the local view of change is quite different to the one of Western scientists, and people are affected in ways that are not always obvious, or predictable, from the large-scale models.

Critically, these studies show that when scientists talk in the abstract of climate, the locals talk of weather (see Ingold and Kurtilla 2000, and papers in Krupnik and Jolly 2002). As Ingold and Kurtilla state 'climate is recorded, weather experienced' (Ingold and Kurtilla 2000: 187). In this way, the difference between studying sea-level rise at the large scale as compared to the local scale is also the difference between *recording* it and the *experience* of it. It is this – the experience – that is of most interest to the anthropological discussion.

There are further similarities with modern discussions of climate change, too. Salick and Byg (2007: 4) point out that: 'the IPCC [Intergovernmental Panel on Climate Change] II report summary on climate change impacts makes only scarce mention of indigenous peoples, and then only … merely as helpless victims of changes beyond their control'. This can be compared to archaeological discourses that either do not mention how people may have perceived or reacted to sea-level rise (for example, Peeters *et al.* 2009), or describe hunter-gatherers as passive victims of their environment (see examples discussed in Leary 2009: 230). This view, with roots that extend back to the colonial period, obfuscates social reality and limits discussion.

This chapter focuses on the experience of landscape change during the Mesolithic period by discussing the perceptions of these events and some possible human responses to them. It therefore hopes to shift the focus back onto people – the primary agents – by discussing vulnerability, adaptive capacity, and resilience, which are now common points of departure for discussions of climate change (see IPCC 2007; and papers in *Global Environmental Change* 19, 2009). Discussions using such an approach emphasize how coping with environmental change can reveal people's relations to the environment as well as indicating how they provide opportunities for social change. Literature that discusses modern indigenous observations, experiences, and adaptations to changing landscapes (particularly those in the circumpolar North, who were among the earliest communities to feel the affects of modern-day climate change) is also cited. It is hoped that using these combined approaches, the complex nature of human reactions to environmental change can be explored.

The effects of sea-level rise and vulnerability

Vulnerability refers to the degree to which groups are differently susceptible to risk, highlighting how separate sectors of the community may be differentially vulnerable to the same danger. It developed from the field of natural hazards, which focused particularly on how social, economic, and political conditions can influence people's ability to cope with and recover from hazards (e.g. Blaikie *et al.* 1994; Hewitt 1997), and is now commonly used in the study of environmental change. In this latter sense it refers specifically to the sensitivity of a community to exposure to climate change and the capacity to adapt (Ford and Smit 2004; Ford *et al.* 2006; Pearce *et al.* 2010; also see the definition in IPCC 2007: 21). Vulnerability is therefore relevant to our study here, and we should not see all communities living in Northsealand[1] as being equally affected by sea-level rise.

Clearly different communities would have been differentially vulnerable, i.e. some communities will have been located further from regions prone to land and resource loss, while others would have been directly, and perhaps drastically, affected. Further, the risks, which are themselves socially constructed, differ even in neighbouring areas,

since coastlines vary greatly between localities, and so whilst a beached shoreline may be submerged by sea-level rise, a cliffed coast may be eroded and become dangerous – again the local scale is important.

The main vulnerable regions in Northsealand would have been the coastal areas, particularly estuaries, which would have been pushed inland, considerably shortening rivers. As Bell (2007) notes, the reduction of the length of river valleys as well as the loss of land due to inundation in the coastal regions would have had a major effect on territory size. This is likely to have affected a substantial proportion of the inhabitants since activity may have focused on coastal regions, and offshore islands. Indeed, small islands would have been particularly vulnerable given the high ratio of shoreline to land area, making inhabitants highly susceptible to damage from rising sea levels and wave damage. Greater vulnerability, as well as an insularity and remoteness of groups on such islands, may have provided a feeling of being marginalized.

Coastal systems are complex and non-linear and small changes can have large implications. Effects of sea-level rise will have included the loss of salt marsh – an environment rich in resources, whilst coastal embayments and tidal inlets are likely to have infilled due to changes in the coastal regime. Deltas and estuaries also have resource-rich environments and would be particularly vulnerable to increased salinity or inundation, displacing or removing the existing coastal plant and animal communities. Changes to freshwater inflows into estuaries further alter the system, resulting in significant effects on, for example, phytoplankton populations and fish nurseries, whilst an increase in water temperature could affect algal production and therefore the availability of light, oxygen, and carbon for other species (Nicholls *et al.* 2007). Although there may not have been a catastrophic breaching of the straits of Dover, the effect on the tidal regime when the North Sea and English Channel finally met would have been colossal, with chaotic tides initially, and palaeotidal modelling (Austin 1991) suggests there would have been a rapid increase in tidal range at this time (see Long *et al*. 1996, for possible archaeological evidence of this). The disruption to the food chain following this event would have been considerable, affecting fish and shellfish populations and other marine resources, and thereby influencing and changing people's diets.

Salt water will have intruded into coastal surface waters and freshwater aquifers, contaminating them and making them unusable for drinking water. This may have affected individuals' health and made it a challenge to find sources of drinking water, particularly on islands formed as lower-lying areas of Northsealand were inundated. As coastal inundation continued, salt water would further encroach inland into river systems; its landward reach extended by storm surges or other high energy events, shortening the rivers and removing resources. Freshwater lakes within Northsealand would eventually have been breached by the sea, killing the fish in an instant and rendering the lake water undrinkable. Such encroachment would have truncated paths (cf. Leary 2009: 231), impacting on individual's travel routes, and may have either removed or blocked access to traditional hunting grounds. The loss of traditional paths may have had considerable social implications if they were bound up with cosmogonies.

As sea level rose, groundwater in areas immediately adjacent to the coast also rose, drowning trees and producing what Fischer (1997: 31) has called a 'killing zone' made up of swathes of dead woodland, the remains of which have been recorded at a number of coastal sites (cf. Pedersen *et al.* 1997; Bell 2007). Consideration should be given to the significant loss of resource this would have posed to local communities and how these dead woodlands may have been viewed (Leary 2009: 231); from firewood and timber for building or renewing houses and other purposes, to the loss of plants and fungi – some perhaps important foodstuffs, others medicinal or even sacred. Additionally, there would have been the loss of large herbivores, which would have moved on when the ground became waterlogged, and when there were no green woodland shoots to graze from or leaves to provide camouflage; and birds too, such as owls, unwilling to inhabit an area where they could no longer hunt mice and other small prey. Further, resources may not represent the only loss: specific woodlands, or locations within woodlands such as clearances, may also have had spiritual significance; perhaps wrapped up in myths and stories, or thought to be places where the spirits dwell, whilst certain landforms may have been considered the physical representations of deities. As woodlands died, the whole ecosystem would have been irreversibly altered, and with it fundamental perceptions, understandings, and interpretations of the place.

The emotional effect of sea-level rise

There is another side to landscape change: such consequences do not come without considerable personal stress. That is to say, people are bothered by *their* land changing, and the changes to their lifestyle this entails – it causes a degree of ontological stress. Changes to the environment do not simply affect subsistence practices, but the individual and community's health and wellbeing, and people relate to the changing environment emotionally.

To Tibetans, for example, the snow-capped mountains are the physical manifestation of powerful deities, and thus recent melting snow causes 'great anxiety and distress' (Salick and Byg 2007: 19; Byg and Salick 2009). Inuit elders have, in recent times, expressed frustration and disappointment that traditional methods of predicting the weather are no longer working; they cannot predict the weather as they have previously done, and this causes considerable distress since not only can they no longer advise people on when to travel, but 'their personal relationship with the weather has changed' (Fox 2002: 43).

This latter point sheds considerable light on the way people relate to their territory (landscape and seascape) – it provides identity and people have a personal and intimate relationship with it, and when the environment becomes unfamiliar and its behaviour unpredictable and unexpected it creates an emotional response. The hunters in Nunavut, Canada, who have had to change their hunting strategies and the locations of their campsites, 'miss' the areas in which they used to hunt. 'In some cases, these places have special significance to family heritage or hold meaningful memories for individuals. Many hunters and elders are extremely attached to the places they come from and travel. They are tied to the land through their intimate knowledge of its paths and processes, but also through emotions and a sense of identity' (Fox 2002: 44). How this may also be true of the Mesolithic, i.e. whether 'place' provided such a deep sense of identity to mobile hunter-gatherers as it does to more settled communities, is uncertain. Sites such as Star Carr, however, do show that persistent places were important, and what is certain is that any loss of land would have disrupted social practices and notions of place. Specific natural features may well have been considered animate and fundamental to the traditions and histories of people and perhaps linked through genealogies. The loss of these features and places through sea-level changes would have been deeply emotive and indeed could have profoundly affected their very place in the world.

Multiple stresses: sea-level rise, tsunamis, and climatic variability

Vulnerability to sea-level rise is likely to have been exacerbated by the presence of other stresses, reducing adaptive capacity and resilience because of resource deployment to competing needs. Multiple stresses that affect exposure and sensitivity, as well as capacity to adapt, include food insecurity and conflict. Or, indeed, tidal waves from the Atlantic, such as the suggested Storegga Slide tsunami recorded from Howick Burn, Northumberland (Boomer *et al.* 2007; Weninger *et al.* 2008), eastern Scotland (Smith *et al.* 1985; Long *et al.* 1989; Dawson *et al.* 1990; Smith *et al.* 2004), the Faroes and Shetland Islands (Bondevik *et al.* 2005), and the east coast of Greenland (Wagner *et al.* 2007) and which would have had a considerable and devastating effect on the landscape of Northsealand and its inhabitants. Arguably, it is the regions most vulnerable to tsunami impact – the coastline and river valleys, lowlands with gently inclined coastline, salt marshes and mudflats – that most attracted the contemporary population, and Weninger *et al.* (2008: 16) suggest that 'a number of local bands, or possibly a regional dialectical tribe' may have been extinguished. Weninger also gives some consideration to other elements of the impact, for example the loss of productive areas, shellfish beds, fixed fishing facilities, and stored food.

Evidence for the climatic conditions during this period indicates that they were highly variable (see, e.g., Anderson 1998; Anderson *et al.* 1998; Macklin *et al.* 2000; Magny 2004; Mayewski *et al.* 2004) with increased chances of changeable and unstable weather patterns, and this will have produced its own set of multiple stresses that are worth considering in some detail. More frequent wind storm would have meant heavier wave action, thus increasing the deterioration of the shoreline and associated ecosystem loss. Combined with sea-level rises this will have had a devastating effect, particularly when a critical threshold, such as a natural levee, was overtopped, inundating the floodplain, and causing an irreversible process of drowning. The erosion of natural coastal systems such as wetlands or beaches removes the natural defences

of coastal communities against extreme events such as storm surges, energetic swell, or tsunamis, making them more exposed and vulnerable (Nicholls *et al.* 2007). Less predictable conditions would have also made it difficult for people to understand the weather and know what to expect from it or forecast it. This is likely to have made travel and hunting more difficult, since it increases the chances of being caught out in a storm or getting lost. Wind direction can also be used for navigation across both land and sea, and therefore rapidly shifting or unpredictable winds may have made navigation more difficult, such as has been recorded in the Canadian Arctic today (Bradley 2002). Stronger winds and more violent wave motion on the coast may have resulted in dangerous boating conditions (cf. Tipping and Tisdall 2004) and therefore caused a drop in hunting and fishing opportunities.

Rougher waters may also have led to fewer seals in the area and perhaps changed fish and seal migrations, as well as affecting fish migrations upstream, such as salmon (which is evidenced from Mesolithic sites, cf. Pickard and Bonsall 2004), upsetting the location and timing of harvesting. Major storms can also clear tracts of woodlands (Brown 1997: 140–1), further removing resources and changing ecosystems.

Indeed, greater climatic variability will have brought profound changes to the nature and distribution of birds, animals (including sea mammals) and vegetation, and some species will have increased in numbers whilst others decreased or disappeared altogether, such as horse and reindeer at the start of the Holocene (cf. Tipping 1994; Spikins 1999; Macklin *et al.* 2000; Tipping 2004; Tipping and Tisdall 2004; Tipping *et al.* 2008, regarding vegetation changes during this period). There will also have been incidences of different species, and these no doubt offered new resource opportunities, which would have been quickly exploited. However, the changes would inevitably put pressure on the established round of annual subsistence activities and its overall productivity, and lead to changes in traditional hunting grounds. Further, the changing availability of vegetation will have led to a shift in the behaviour and migration routes of animals such as deer, attracted by richer vegetation for forage and refuge, as well as their selection of calving grounds, whilst traditional migration routes may have become blocked and inaccessible due to inundation of land and changes to river systems. Changes to the temperature and the environment would also mean that some birds arrived and migrated at different times, for example warmer temperatures would have led to wintering geese arriving later and leaving earlier, meaning fewer eggs were laid and reducing opportunities to hunt them.

Further to this, sudden environmental changes, such as the drop in temperature around 8200 cal BP (Barber *et al.* 1997), are likely to affect the health and body condition of animals and lead to, for example, the death of bird chicks and deer calves. Unusually hot weather will cause larger animals to overheat, become exhausted and thin, leading to lower population levels. In Nain, Labrador, modern environmental changes are thought responsible for a greater number of sick and diseased animals, particularly parasites in the liver of caribou, which affects the taste and texture of the meat (Furgal *et al.* 2002). A similar process may have been observed in populations of large herbivores during the Mesolithic.

Warmer weather in the Arctic has also increased the number of mosquitoes, which not only harass the caribou, influencing their health and distribution, but are also a nuisance to people, making travelling, hunting, and camping more difficult (Thorpe *et al.* 2002: 214). Few archaeologists have considered the role of mosquitoes in the Mesolithic. Indeed, it is reported that rising temperatures in the Canadian Arctic are affecting the caribou in ways that we could not know from the archaeological record, for example the meat now tastes different to the Inuit, and the skins are of poor quality (Fox 2002) – probably the result of poor vegetation growth on which they feed, or changing vegetation, which then affect the health of animals.

Changes in the temperature will also alter river and lake levels (Digerfeldt 1988; Sarmaja-Korjonen 2001; Macklin and Lewin 2003; Magny 2004), which in turn will affect the size of the fish, whilst warmer water temperatures may well increase the presence of parasites in fish. Periods of aridity would have affected some foods, such as berries, since a greater intensity of sun will make berries smaller or shrivel them thereby affecting their availability for consumption. Whilst heavier rains (as suggested, for example, by a shift to wetter conditions toward the end of the Mesolithic: Tipping 1994; Anderson 1998; Tipping and Tisdall 2004; Tipping *et al.* 2008) could have affected, for example, bee populations and thus

the pollination of fruiting species. Changes such as these could have had a profound influence on human diets and resulted in people making considerable adjustments to their usual activities, to say nothing of the previously mentioned effect on people's ontological understanding.

Adaptive capacity and resilience

Adaptive capacity is the ability to adapt to changes in the environment, to moderate and mitigate possible damage, to take advantage of opportunities, and to cope with the consequences. It is, in other words, the process of learning and adjusting practices, and the environment, to manage and take advantage of the local conditions (Ford *et al.* 2006; IPCC 2007; Pearce *et al.* 2009). Again, adaptive capacity differs not only between communities (some communities will have been better placed to adapt than others, that is they may have had greater access or entitlements to resources, better adapted to exploit terrestrial resources, or have advantageous social networks), but within communities too (some people will have been more skilful or more experienced than others and therefore likely to have taken advantage of certain situations quicker). Adaptive capacity is dynamic and a wide array of responses could be available, ranging from the technological to the behavioural. These responses are, however, local or regional in scale, since decisions are made at the individual, household, or community level, and both the costs and benefits are accrued locally.

A number of strategies enhance resilience and enable people to both absorb and recover from changes, and to learn from and adapt to them. Resilient strategies may include being flexible and able to move quickly to exploit any positive opportunities that might arise, as well as to monitor ecosystems and resource stocks. Resilience can be enhanced by the diversification of the supply of food, an intensification of resource use, or by turning toward more readily available, but perhaps less favoured, foods. Imposing restraints or even taboos on certain resources may also be a way of protecting them for the future; indeed, looking ahead and nurturing resources in general is a resilient strategy. The sharing of resources between and across communities, and an increase in social interaction and alliances generally can be resilient strategies. Experimentation, innovation, and creativity may also increase the number of choices available to a group and are possible responses to the changing land, and this may include for example the adoption of farming (Bonsall *et al.* 2002; Tipping and Tisdall 2004), illustrating how climate change may have provided opportunities for social, technological and economic change.

Greater group mobility, including the ability to relocate temporarily and permanently, and indeed migration away from the submerging land may be successful adaptations to sea-level rise (for a discussion of the possible interactions and movements of inland and coastal Mesolithic groups, see Passmore and Waddington, in press). Migration is, however, not simply an environmentally determined process; social aspects are far more important in shaping the decision to migrate from one's own homeland. For example, a general loss of faith in the future of Holland Island, Chesapeake Bay, Maryland, USA was responsible for abandonment in 1920 long before it became uninhabitable due to sea-level rise and loss of land (Arenstam Gibbons and Nicholls 2006), whilst the opposite is true of Funafuti Island, Tuvalu, in the South Pacific where people choose to remain on the island despite significant land loss and continued sea-level rise; factors for staying include a sense of identity and lifestyle provided by the island, as well as a strong faith that God will protect them (Mortreux and Barnett 2009). Although these examples cannot be directly compared with prehistoric hunter-gatherers they do serve the purpose of showing people's wide, and sometimes contrasting, responses to sea-level rise, and how decisions are frequently made on the basis of ontology as opposed to simple adaptive responses.

Encoding a variety of terms for recognizing changes to the landscape within language can be a way of precisely and accurately communicating information and observations. Whilst oral traditions, story telling, ceremonies, music, and artistic representations may be a further way, and can include information about how to deal with, and what to expect from, the changing coastline (see Leary 2009: 234), as well as a way of expressing human emotions to the loss of land, or even keeping destructive, and perhaps tragic, events alive in peoples' minds.

Accumulated knowledge and resilience

Adapting to sea-level rise and the associated land and resource loss can be significantly

enhanced by a detailed knowledge of the local environment. Indeed watching, understanding, interpreting, and predicting the weather is a vital activity and an integral part of daily life in many modern societies, and the more precise one's observations are, the better the forecast. In the Arctic, watching the weather is a respected task and people spend hours scanning the horizon and discussing indicators (Krupnik 2002). Just as the ecosystem is an intricate web of relations, so people, environment, birds, animals, plants, beliefs, and weather are interrelated; they are in ceaseless motion with one another. Relationships are drawn between temperature fluctuations, wind strength and direction, wave energy, people's safety, animal behaviour, vegetation growth, and hunting success; and people have a finely-tuned awareness of these ever-changing relationships. Through this people learn to predict the weather, read the terrain, judge the conditions, and predict animal movements and distributions. In other words, they learn about their environment by actively engaging with it. And it is through many years of mentoring with someone more experienced that one learns to combine personal experience with generations of observed correlations between weather, land, sea, and animals by the elderly experts, and this in turn increases resilience to change. It helps people to construct knowledge of how to deal best with their changing environment. In this instance, knowledge of the weather is not simply handed down through generations as a cultural package, but is accumulated; it 'grows through a lifetime's experience of living in a place and moving in its environs' (Ingold and Kurtilla 2000: 187).

Without drawing a direct parallel between the British Mesolithic and Arctic communities today, it is likely that knowledge of the Mesolithic environment, and any changes to it, were accumulated through a similar experience of engagement; through continuous observations and daily encounters with the environment. The same point has been made by Mithen (2000) who points out that Mesolithic sites in the southern Hebrides are mostly located with good views across the land: 'In general, the selection of sites with good viewsheds should not be surprising. Hunter-gatherers rely on information about their changing landscape: they constantly, informally and to some extent unconsciously, monitor the movement of animals and birds, the changing skies and light conditions. The Mesolithic people in the southern Hebrides would have been naturalists *par excellence* …' (Mithen 2000: 605).

Through such deep phenological data, people could develop a detailed knowledge and sensitivity to changes in the environment – an understanding of when thresholds were likely to have been breached, the significance of dead woodlands, and the likely effect on resources and territory size. Adaptations could then be formulated. These may have included avoiding areas vulnerable to flooding or collapsing cliffs, or perhaps making changes to subsistence patterns or adjustments to the timing of the seasonal calendar, such as changing the times they hunt and harvest food, the length of time they go out for, modifying their hunting locations to reflect changes in the distribution of animals or vegetation growth, or switching species and exploiting a mix of species, thereby minimizing risk and uncertainty. By *actively engaging* with their surroundings and monitoring the environment, Mesolithic hunter-gatherers could build an *accumulated knowledge* of their changing environment that then increased their *resilience* to the changes taking place.

Conclusions

Perceptions of, and responses to, past sea-level rise are only rarely considered in archaeological discourses despite the fact that people lie at the heart of archaeology; the aim of this chapter is to show how people and communities were affected by, and reacted to, sea-level rise. I have argued above that although sea-level rise occurred on a millennial and global scale, it unfolded on a generational and local level. The local scale provides us with a better understanding of the effects of sea-level rise, a sense of the experience of it, rather than simply recording sea-level rise as an abstract concept. Further, an ethnographic approach provides us with an impression of the subtle links between people and their environment, and the knowledge that is accumulated by an engagement with it. This knowledge is localized, and therefore the local scale can identify problems that are not necessarily obvious from the larger scale; it gives us a more complex look at environmental change.

Future work must, therefore, emphasize the local and regional scale over the global, and develop local-scale models of change. With these local-scale models we may then begin to

understand the nature of Mesolithic vulnerability to sea-level rise, in terms of the people and their capacity to adapt to change, and what resources were vulnerable to what stresses. I have tried to capture some of the nuances of environmental change that are frequently missing from the archaeological literature, and have highlighted the close and intense relationship between humans and their environment. Sea-level rise, and associated changes, provide a lens through which to investigate this relationship and as such can be considered an excellent venue for further human–environment study.

Note

1. 'Doggerland' was a term coined by Bryony Coles (1998) in honour of Clement Reid's suggestion that the area was once dominated by the 'Dogger hills' (now the Dogger Bank). Seismic data suggest, however, that the Dogger Bank is largely the result of recent submarine deposition and would not have been an obvious topographical feature during the Early Holocene (Gaffney *et al.* 2009: 68). Vere Gordon Childe had previously named the area 'Northsealand' (Childe 1958: 27–9) and this is the term favoured here.

Acknowledgements

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8

Submerged Landscape Excavations in the Solent, Southern Britain: climate change and cultural development

Garry Momber

At the start of the Mesolithic some 11,500 years ago, Britain was a peninsula of Northern Europe. The North Sea and eastern English Channel would have been a low-lying plain interspersed with hills, rivers and wetlands enabling access across territories from western Russia to Scotland, facilitating a steady groundswell of common culture. It took around 4000 years before Britain finally became an island and the proto-North Sea was formed. As the sea encroached, territories reduced but this was countered by a growth in productive estuaries, sheltered archipelagos, and maritime coastlines hosting rich ecosystems that would have been subject to increased population density. The impact of rising sea levels on societies before, during, and after final severance would have been acute and in some cases devastating as people were either forced to move, were isolated, or wiped out. When Britain became an island, the physical links with Europe were removed and cultural nuances developed along separate paths. This chapter examines some of the dichotomies between the British and European Mesolithic. It looks to the submerged palaeolandscape as a resource that could provide the answers to the apparent cultural divergence. The investigations at Bouldnor Cliff are presented as a case study that has revealed unique and significant artefacts demonstrating the potential to open the door on this little understood phase of North European human dispersal.

Keywords: Bouldnor Cliff, Solent, underwater archaeology, submerged landscapes, Mesolithic, climate change, human dispersal

Introduction

The sea-level rise during the Upper Palaeolithic and Mesolithic inundated vast ranges of the occupied land, displaced populations, and disrupted avenues of communication between Britain and continental Europe (Shennan *et al.* 2000; Lambeck and Chappell 2001; Bailey 2004). This loss, which would have had an irrevocable impact on the inhabitants, is now of benefit to archaeologists with the ability to look underwater. Ongoing discoveries have shown that where artefacts and sites are not destroyed they can remain preserved in saturated anaerobic sediments for thousands of years (Reid 1913; Coles 1998; Flemming 2004; Gaffney *et al.* 2007).

This chapter assesses the potential value of the cultural resource within these submerged lands as a primary archive for the interpretation of Mesolithic cultural progression during a time of great change. Some of the rich discoveries found at the submerged site of Bouldnor Cliff off the Isle of Wight, UK, will be presented. This case study will serve to validate the potential for the existence of similar sites that could inform our understanding of human adaptations as we map the impact of physical severance from the continent.

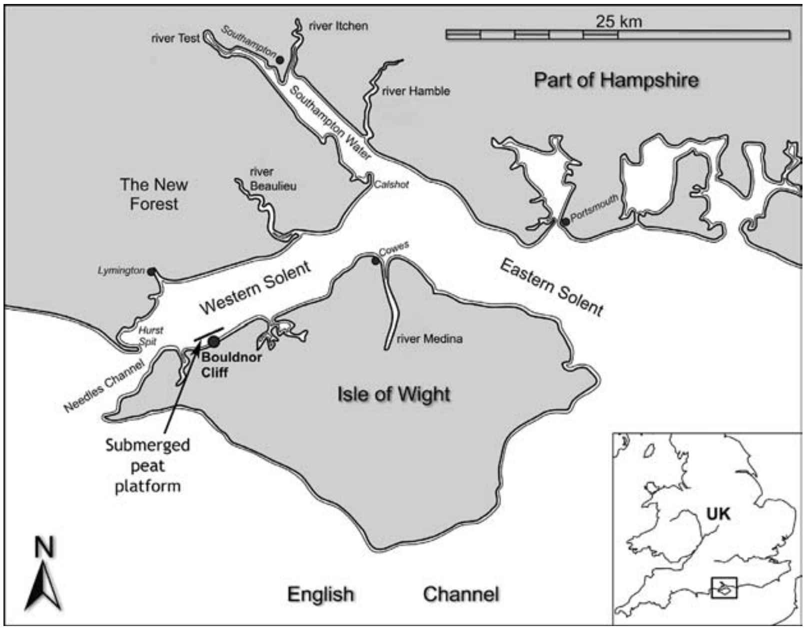

Figure 8.1: The Solent showing the location of the submerged peat platform at Bouldnor Cliff

The submerged lands of the Solent

Investigations of the 11 m deep submerged forests off the north shores of the Isle of Wight at Bouldnor Cliff have been ongoing intermittently since the 1980s, but it was not until 1999 that the first archaeological discovery was made by the Hampshire and Wight Trust for Maritime Archaeology (HWTMA). This has been followed by annual inspections and a series of fieldwork projects primarily supported by English Heritage in 2003 and the Leverhulme Trust in 2007.

The fieldwork has tested the archaeological potential of an 8000-year-old peat terrace that runs parallel with the coast for over a kilometre (Fig. 8.1). The peat protrudes from beneath protective sediments that were deposited above it as sea level rose (Fig. 8.2). Samples have been collected from the submerged landform and small evaluation trenches excavated. The results from the investigations have been presented in a number of interim publications as new information has come to light (Momber 2000, 2004, 2006; Tomalin 2000a; Momber *et al.* 2009). The studies have built a picture of the palaeoenvironment, the palaeolandscape, the manner of inundation, and the subsequent erosion.

Geomorphological evolution and site formation processes

Of great importance to any archaeological interpretation of inundated landscapes is knowledge of the site formation processes. The process that determines the progression from deposition to erosion or vice versa will dictate the preservation of the submerged land surface. Interpretation of that process will help recreate the palaeolandscape, which in turn can aid with modelling the location of Mesolithic sites (Fischer 1997; Peeters 2009a). Conversely, when anthropogenic activity is detected, consideration of the contemporary physical surrounding is of key importance when interpreting functional features and artefacts.

The creation of the proto-Solent has been of interest to academics for many decades. Until recently, it was believed to be a large river running from east to west across the north of the Isle of Wight. However, research by Velegrakis demonstrated that the river turned south before it reached the Isle of Wight (Fox 1862; Everard 1954; Allen and Gibbard 1993; Velegrakis 2000). A hypothesis that the western Solent was drained by a much smaller south flowing river, the River Yar, was proposed by Reid (1905) and then by Tomalin (2000b), but evidence has not been available to substantiate these propositions until deposits along the fringes of the Solent waterway were scrutinized. This took the form of bathymetric survey in conjunction with sedimentary, diatom and foraminifera evidence from select sediment archives at Bouldnor Cliff (Dix 2000; Scaife 2000, in press; Momber *et al.*, in press). The analysis has revealed a sequence of events that began with a river running north to south from the New Forest, through Lymington, across the western Solent, past Yarmouth, and out along the course of the River Yar cutting the chalk downs at Freshwater. The rise in sea level introduced estuarine sediments up the River Yar around 6000 cal BC, followed by the deposition of brackish, estuarine sediments covering and protecting what was a sheltered basin. By *c.* 4000 cal BC rising sea level overtopped land to the east of the basin and a couple of thousand years later the land barrier to the west was also breached. Radiocarbon dated vegetation from a drowned landscape 2.5 m below Ordnance Datum (OD) and immediately to the west of Hurst Spit gave a date of 1900–1690 cal BC (Beta-270797). The deposit from which the sample came is known to

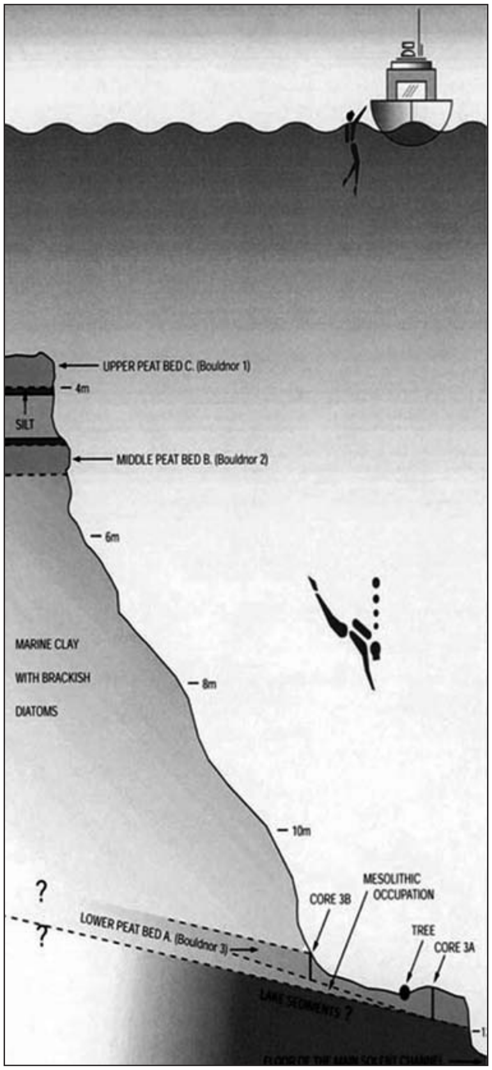

Figure 8.2: Schematic section across the submerged Bouldnor Cliff (Courtesy Isle of Wight Coastal Centre)

extend beneath the spit and would have formed an umbilical of high land that was breached when the Solent formed. Once water was able to pass from east to west, attrition from tidal currents would have begun to cut a channel, turning a sedimentary system into one of erosion (Momber *et al.*, in press).

The palaeoenvironmental evaluation in 2003, funded by English Heritage, demonstrated that the Mesolithic environment before inundation was associated with fen, a freshwater wetland and, possibly, a lake or river floodplain. This is an area that would have provided a sheltered refuge with accessible resources – in direct contrast to the landscape suggested by the current seabed, which infers a large river.

The complex scenario of varied and dramatic impacts that changed the landscape as sea level rose would not have been unique. As such, it highlights the need for informed investigation in order to determine the survival of buried terrestrial deposits.

Archaeological evidence and interpretation

Archaeological investigation in and around an evaluation trench in the area known as Bouldnor Cliff II (BC-II) has uncovered 83 worked flints (Fig. 8.3). Most of the lithics were flakes and debitage with a few retouched pieces, although the discovery of tranchet flakes attributed to the production of axes or adzes proved intriguing. On analysis, David Tomalin noted that one such bifacially prepared tranchet axe sharpening flake displayed care and symmetry usually associated with Neolithic craftsmanship (Tomalin, in press). These were recovered from the foot of the submerged clay cliff and from beneath stratified peat at a depth of 11 m below OD (Fig. 8.4). The host deposit from which the flints came represents a streamside environment that had once flourished close to a wetland or lake (Scaife, in press; Robinson, in press) that had turned into brackish water and saltmarsh by *c.* 5900 cal BC (Hamilton *et al.*, in press; Heathcote, in press).

A second major area of interest in the submerged landscape was identified in 2004. It lay 11.4–11.6 m below OD, 420 m WSW of BC-II where it is being uncovered from the northern edge of the basal peat platform. The locus was suspected to be rich in archaeology following the discovery of a pit containing burnt flints and fragments of wood, which has been interpreted as anthropogenic.

Figure 8.3: Examples of worked flints from the stratified deposits of BC-II

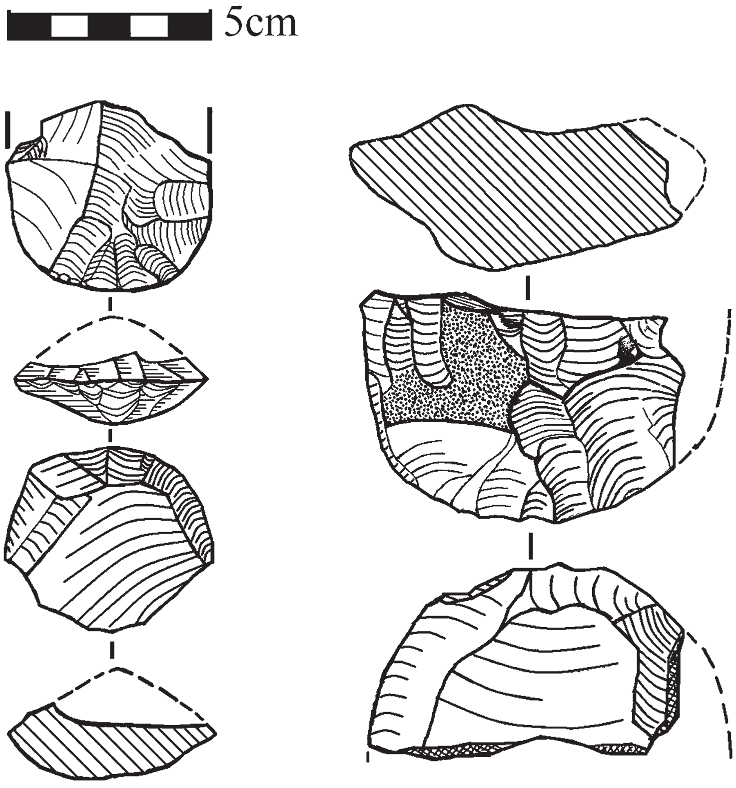

Figure 8.4: Tranchet axe sharpening flake and axe or chopper fragments (Drawn by David Tomalin)

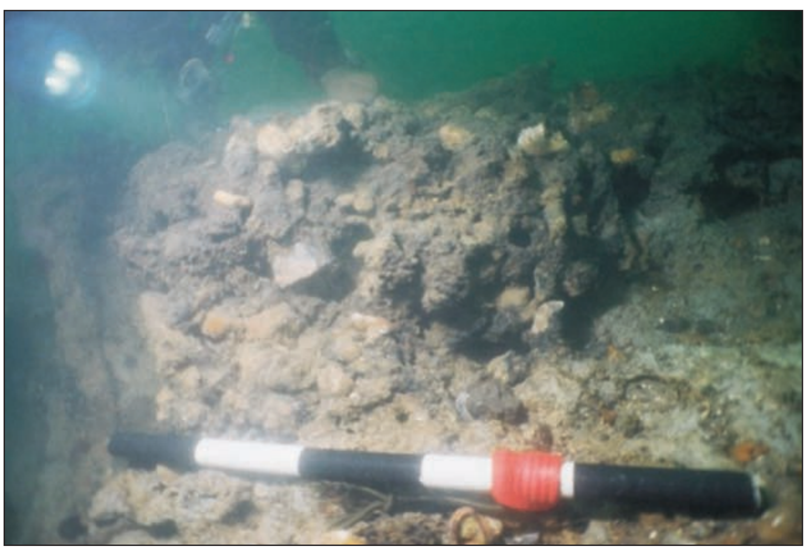

Figure 8.5: Pit full of burnt flints found at the eroding edge of the peat shelf

The pit containing the burnt flint had been 'sectioned' by erosion and its contents were found spilling out onto the seabed below (Fig. 8.5). The remaining portion, measuring 45 cm wide by 40 cm deep had a clear outline indicating it had been dug into the old land-surface. A soft, organic-rich, silty clay covered burnt material comprising heated clay nodules, charcoal, and burnt lithics. The seabed at this point is 11.55 m (±0.15 m) deep. A piece of alder from the pit was radiocarbon dated with the posterior density estimate (95% probability) results giving an age of 6120–6010 cal BC (OxA-15699). When the final section of the pit was removed and examined, burnt layers indicated repeated use showing that heated stones were deposited in the pit on more than one occasion.

Another feature was recorded 1.3 m to the west of the pit. It comprised wood of differing shapes and sizes apparently forming a platform elevated 10–15 cm above the surrounding seabed. The feature measured 2.1 m across and had a range and variety of wooden pieces unlike any other feature recorded on the submerged landsurface. The underlying deposits were stratified. The topmost layer of fine, humified peat contained flat and roundwood. Immediately beneath was a mottled grey clay with burnt flint flakes and black organic material, which appeared to be resting on a basal horizon of twigs. A piece of alder recovered from just above the layer of twigs was impaled by a piece of worked flint (Momber and Campbell 2005). The piece of alder provided a 2-sigma calibrated age of 6100–5880 cal BC (Beta-209564). The intercalated mixture of sandy silt and cultural remains could be seen in the naturally cut section (Fig. 8.6).

Another piece of roundwood with evidence of working was found 20 m to the west. The surviving section was 0.32 m long and had been exposed as the seabed sediments were eroded. A small segment of wood had split from the main piece and bent beneath the tip, indicating that it was a wooden post that had been forced into the ground (Fig. 8.7). The timber was subsequently analyzed by wood specialist, Maisie Taylor, who concluded that it had been torn from the parent tree where chopping was used to cut through the final connecting strands of wood (Taylor, in press).

Monitoring over the next few years saw rapid erosion. In 2007, the Leverhulme Trust, through the University of York and the HWTMA, supported work to recover and record further samples of seabed from small evaluation trenches to help characterize the extent and potential of the archaeological remains. Most of the samples were collected in galvanized steel tins measuring 200 mm long by 250 mm wide by 330 mm deep. Evidence recovered from around the eroding features included charcoal, worked wood chippings, burnt flint, roasted hazelnuts, and prepared string (made of some, as yet,

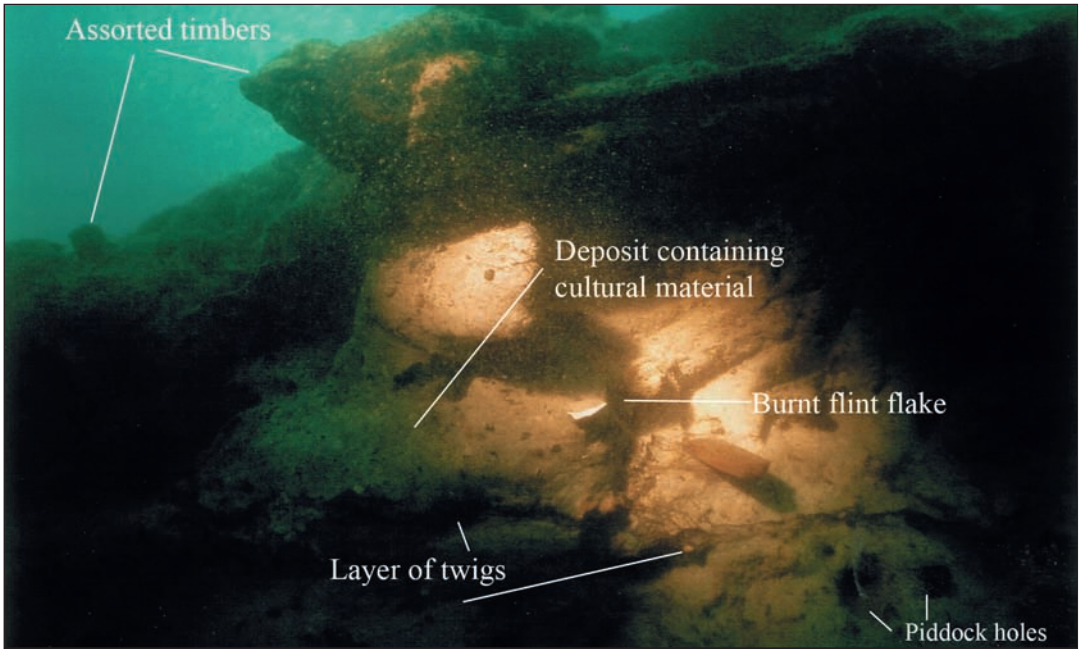

Figure 8.6: Eroded section showing assorted fragments of wood sitting on top of a 30 cm thick cultural deposit underlain by a layer of twigs, plus alder branch impaled by a burnt flint that had been worked

unidentified material). The finds occurred in a distinct stratified horizon that contained abundant burnt flints (Fig. 8.8).

Two metres to the south of the platform edge another concentration of wood fragments, which had become exposed beneath the peat, was investigated. An area approximately one-and-a-half metres square was uncovered, revealing 13 pieces of wood lying next to and across one another. The concentration was surveyed and the most vulnerable pieces were recovered. The pieces of wood were analyzed by Maisie Taylor who concluded that, 'all appear to have been modified by humans in some way. Some pieces show clear and definite signs of working, whilst others are less clear' (Taylor, in press). Figure 8.9 shows an example of the cut-marks observed on the timber.

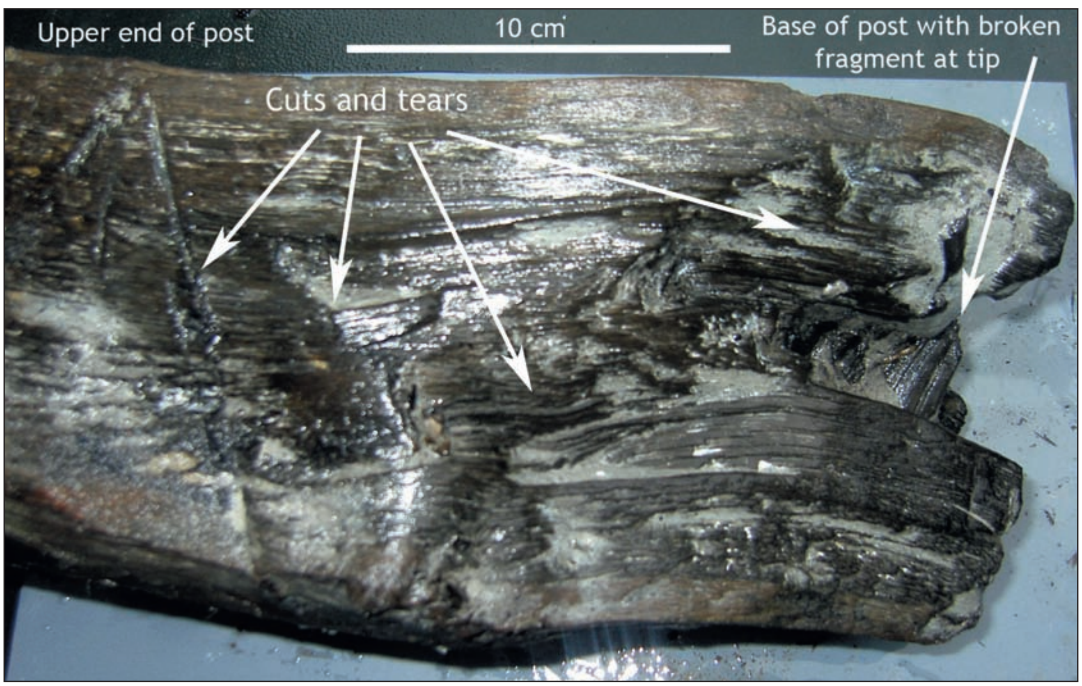

Figure 8.7: Base of post with marks cut into the timber when it was separated from its parent trunk and a broken piece of wood at its tip indicating that it had been forced into the ground

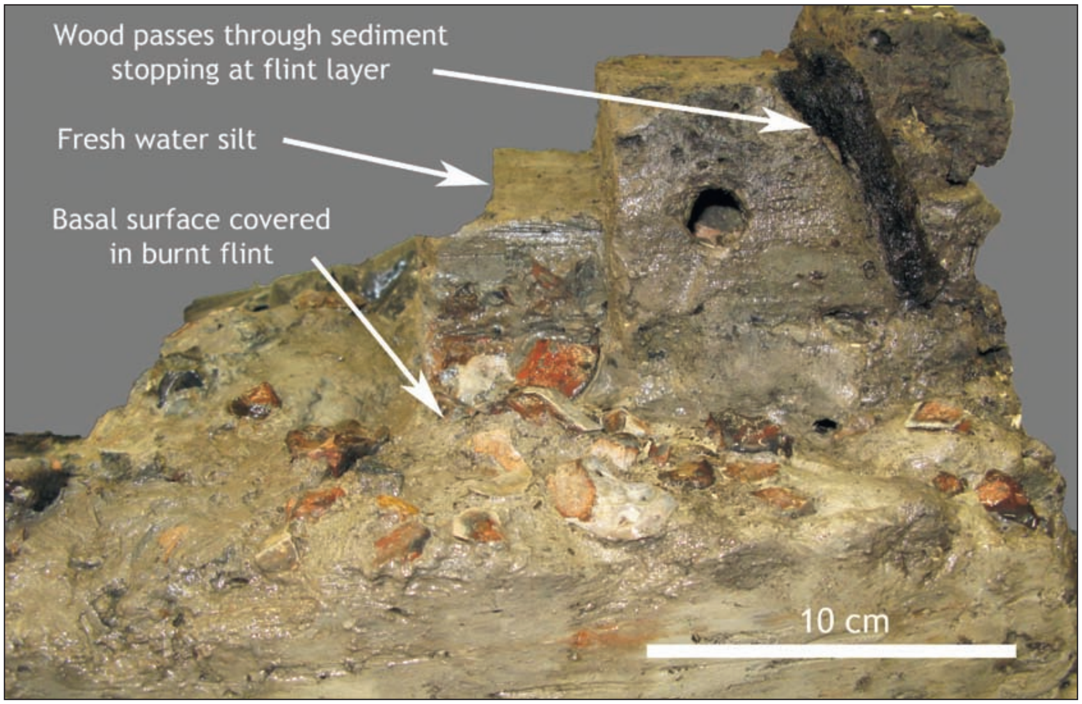

Figure 8.8: The burnt flint occurs within an archaeological horizon from which a range of organic artefacts have been recovered. The vertical piece of wood represents a possible later phase of activity

The piece with the most significant evidence of working measured 0.94 m by 0.41 m. It lay horizontally on the old landsurface and has provided a 2-sigma calibrated age of 6240–6000 cal BC (Beta-249735). The specimen, referred to as BC-F061, tapers at one end where there are signs of burning and it has a maximum thickness of 25 mm (Fig. 8.10). It was described by Maisie Taylor as, 'a large timber of oak (*Quercus* sp.), which has been tangentially split from a big tree and could have been hewn' (Taylor, in press). It is improbable that the trunk was split by natural forces, and the interpretation favoured by the present author is that the timber was deliberately removed from a large oak tree. This method employs wedges to split the tree toward the edge enabling the production of wide flat planks. Once this is removed from the oak bole, around three-quarters of the tree's circumference would be available for further conversion. The relative angles of the medullary rays, which were almost parallel, suggested the timber had been removed from the edge of a tree in the order of 1.5–2.0 m wide. This technique was used to create large, deep, log boats or dugout canoes in later periods, e.g. the Bronze Age boats from Appleby and Brigg (McGrail 1978). These boats were both made of oak, which is the wood used for a number of the post-Mesolithic log boats discovered in Britain and Northwest Europe (McGrail 1978; Okorokov 1995; Mowat 1996).

Evidence from other sites suggests this tangentially split timber could have been part of a monumental structure. Prehistoric timbers using these conversion techniques have been found on the British mainland, although not for another 2000 years. The earliest example is the Neolithic Haddenham Long Barrow *c*. 4000 BC where large timbers of this type were used to construct a chamber to house burials (Evans and Hodder 2006).

Ongoing monitoring in 2009 and 2010 identified more timbers eroding from the bank. The evaluation trench cut in 2007 was extended to record them. Removal of the covering sediment revealed additional interconnected pieces several of which had evidence of cutmarks. One is a 1 m long curved piece with deep grooves and channelling along its inner and outer edges. The function of the worked wood is yet to be resolved. It forms part of a larger assemblage, although the full extent and number of the timbers remain unknown as the feature extends below the submerged bank. The complex arrangement of the worked wooden pieces suggests that a substantial Mesolithic structure once stood in this location.

Although the work is still at the evaluation stage, already it has produced artefacts of a kind rarely found in British Mesolithic sites. The presence of string, flint tools, crafted peg-like roundwood, charcoal, wood chippings, and a

reused pit containing burnt flints, all point to a site of industrial activity. This was set in a natural amphitheatre that would have been ideal for fishing, wildfowling, and hunting in watercourses that would have allowed opportunities for movement in all directions. The sea, with its marine resources, was in the order of 8 km away and could be reached by foot or watercraft. The variety of geographical and ecological systems found within a day's walking distance in any direction from the western Solent basin could potentially have provided resources needed for year-round survival. These included flint from the chalk cliffs, timber, and foodstuffs. It appears that the lowland basin below Bouldnor Cliff offered attractive settlement opportunities. This rich source of archaeological material from the occupied area on the edge of the basin contrasts with the scarcity of Mesolithic occupation sites in the wider region.

It is also worth noting that while the initial visual survey at the second locus covered approximately 60 m^2 of the seabed and evidence of anthropogenic activity was found at points across the whole area inspected, this is only a small fraction of the kilometre long palaeolandsurface exposure. Within the survey area there were many pieces of wood that appeared anomalous when compared with the branches and roots we know to be natural. However, degradation of this 'anomalous' wood caused by exposure to the water column makes definitive interpretation problematic. To access better-preserved material excavation is necessary, but even then the absence of comparable data from the Mesolithic presents a challenge. To overcome this problem there is a need for further discoveries that can enlarge the national database of Mesolithic organic artefacts. Bouldnor Cliff presents an opportunity to address this but, to gain the most from this internationally significant site, material must be recorded before it suffers further degradation and potentially valuable information is lost. To date, only *c*. 1 m^3 of the palaeolandsurface has been subject to detailed excavation.

Assessing archaeological potential and drivers for change

The archaeological evidence informing our understanding of cultural changes through the Mesolithic indicates that they evolved along a number of pathways. Cultural modifications through the period mirror environmental changes that occurred after the abrupt end to the Younger Dryas (Alley 2000). In the early stages of the Mesolithic common tool assemblages, occupation patterns, subsistence, and burial practices appear to cover wide swathes of Northwest Europe (Clark 1932, 1936; Bang-Anderson 2003; Conneller 2009a, 2009b; David 2009; Schulting 2009). The extensive distribution demonstrates the wide-ranging interaction between mobile bands of hunter-gatherers made possible by relatively unrestrained movement across expansive tracts of land.

As the epoch ran its course and climate fluctuated, cultural trends appear to have become more localized. In time, warming temperatures saw woodland vegetation move across the plains and with them, a more disparate variety of animal species (Gumiński and Michniewicz 2003). The increased forestation resulted in the fragmentation of ranges for migratory herds while giving rise to a wider diversity of ecological zones. Movement (at least over land) by humans

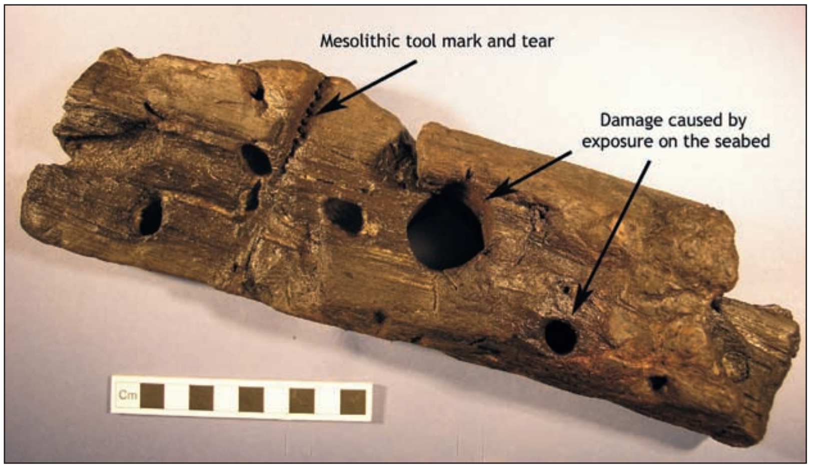

Figure 8.9: The sample of timber contains a deep, clearly defined cut in spite of its poor condition. The cut, which is parallel to the grain, is distinctive as one side is flat and straight, while the other is slightly 'crinkled'

Figure 8.10: Burnt end of a tangentially split timber that was removed from a large oak tree

would now have become more difficult and in some cases less necessary. The result could have been the observed regionalization allowing idiosyncratic traits to emerge, particularly where locations were more isolated. As a consequence technologies and subsistence strategies were adapted to meet new demands. Research by many authors into tool variants, settlement patterns, art, and burial practices has looked to define this longstanding framework and subcultural differences (Clark 1936; Jacobi 1981; Grøn 2003; Bell 2007; Chatterton 2007, 2009; Suddaby 2007; Warren 2007; Conneller 2009b; Schulting 2009; Wickham-Jones 2009).

In Britain, the divergence from the common templates of the Early Mesolithic was invariably a result of adaptation to select ecosystems. This would have been compounded by the inevitable isolation of hunter-gatherer communities over their enormous temporal and spatial spread. Despite the emerging differences, there appears to have been the transition of comparable practices in the later Mesolithic. This is seen with shelters, structures, and tool typologies where the dominance of large sites with many thousands of worked flints gives way to smaller, more numerous assemblages. Notwithstanding occasional exceptions toward the end of the Mesolithic epoch, the large structures constructed for habitation in the first couple of thousand years of occupation recede from the archaeological record as they are superseded by more discrete, less permanent dwelling places (Leakey 1951; Rankine 1952; Clark 1954; Wymer 1977; O'Malley and Jacobi 1978; Barton 1992; Reynier 2000; Wickham-Jones 2004; Gooder 2007; Suddaby 2007; Waddington 2007). The evidence suggests this was part of a gradual progression, although sudden leaps over large distances may have occurred: travel across water to Ireland or the Hebridean Islands being examples (Edwards and Mithen 1995; Woodman 2003). The ability to travel across the sea shows there was interaction with water and the new marine and estuarine ecological regimes associated with sea-level rise would have offered strong drivers for change. The model in the Baltic, where Late Mesolithic communities were attracted to the coastline, provides tangible evidence of human responses to the marine ingress. Research by Rowley-Conwy (1983) demonstrates that the productivity of certain estuarine coastal zones was three times greater than that inland. During the Mesolithic, the rising waters took away a great deal of terrestrial living space but as it did so the encroaching waters increased the number of estuaries and multiplied the length of intertidal coastline in areas such as the Baltic and southern England. A result was the introduction of different ecosystems many of which, but not necessarily all (see Westley and Dix 2006), would have been richer and more productive. On the continent, at a number of locations from Brittany to the Baltic, coastal communities became a focal point and flourished, which resulted in increased coastal sedentism, social development, and technological advancement (Grøn 2003; Fischer 2004; Skaarup and Grøn 2004; Åstveit 2009; Grøn 2009; Sergant *et al.* 2009). In Denmark investigations of submerged sites off the Storebælt and Funen in the Danish Archipelago over the last few decades have produced thousands of Kongemose lithics dated from *c.* 6400 to 5400 cal BC, many associated with old coastal sites (Pedersen *et al.* 1997; Skaarup and Grøn 2004). The quality of the material has been referred to as 'some of the finest … from the Mesolithic in Denmark' (Fischer 1997: 70). This strong archaeological signature is supported by the building of substantial structures and the use of extensive burial practices at a time when people were moving away from a more terrestrial to a marine based diet (Conneller 2003; Grøn, 2003; Skaarup and Grøn 2004; Fischer *et al.* 2007; Chatterton 2009; Jenson 2009; Marchand 2009; Meiklejohn *et al.* 2009; Sergant *et al.* 2009). Within a thousand years the sea level in Denmark was only a couple of metres lower than today and the Kongemose had been superseded by the Ertebølle, which was a culture that concentrated on the exploitation of marine resources (Pedersen 1997; Lübke 2009).

On both sides of the North Sea basin the sites in the Baltic and in the Solent share common traits in their association with lacustrine and estuarine locations. Recent research underwater has revealed that similar Holocene landscapes remain beneath modern sediment in large areas of the North Sea (Gaffney *et al.* 2007). These contain geomorphological features interpreted as lakes, rivers, hills, and marshes. The landscape is protected under sand and silt deposits offering significant potential for preservation. In 1931 an antler harpoon was trawled up from around the Leman and Ower banks (Godwin and Godwin 1933). It was subsequently dated to *c.* 13,600 years old (Bonsall and Smith 1989). Since that

time, thousands of faunal remains and worked flint tools have been recovered by trawlers or gravel dredgers after having been freed from anaerobic sediments beneath the silts or from exposed Pleistocene gravels (Peeters 2009b; Tizzard *et al.*, this volume).

Discussion

The increasing exploitation of coastal resources around 8500 years ago in Northwest Europe occurred when the transgression was pushing inland at a rapid pace, extending coastlines, forcing seawater into the Baltic, and creating large estuaries across the lower European plains. Late Mesolithic communities in mainland Europe responded by exploiting the coastal zone and making it a major part of their subsistence patterns, while the British record is in marked contrast. In Britain, marine resources are exploited at a number of locations but their importance seems to have been relatively limited where coastal exploitation was important for some but not significant for most (Churchill 1965; Palmer 1977; Edwards and Mithen 1995; Loader *et al.* 1997; Allen and Gardiner 2000; Richards and Schulting 2003; Mithen 2004; Bell 2007; Mannino and Thomas 2009; Wickham-Jones 2009).

At Bouldnor Cliff evidence of coastal exploitation has yet to be found. Initially it was a lacustrine site but the sea would not have been more than a few hours away by foot or boat. As only small areas have been investigated along the peat platform to date this is not surprising, but what has been found has greater affinities to continental material than that found in Britain. Indeed, the woodworking skills represented by the discoveries at Bouldnor Cliff indicate a technological ability 2000 years in advance of material found at British terrestrial sites. As demonstrated in the Baltic and referred to above, sites near the coast have been linked to increased technical advancement and semi-sedentary behaviour and they occurred just before the final severance when estuarine conditions would have been at their most extensive. It may be that this period of great change and new opportunity spurred on technical developments while the rising waters increased cultural divergence.

Britain and mainland Europe were ultimately separated by water and although travel by sea was demonstrably possible, as indicated by occupation on islands around the UK, it invariably became more risky as the sea swelled. This presents some interesting enigmas: were the technical skills expressed in the finds from Bouldnor Cliff lost and the original inhabitants forced to change their lifestyle as their preferred environments were overtaken by the sea. Or did these skilled people move to continental Europe where archaeological evidence from the Baltic demonstrates similar skills existed. Or is it simply that we have not yet found other examples on land? Were these artefacts just associated with an isolated group, or were they comparable to similar groupings in equitable environments that have since been submerged? The western Solent was occupied by people who soon found themselves isolated from the Continent by the sea, but the archaeology is more akin to European examples. This suggests a cultural link, which can only be substantiated by looking at the areas between the two places that are now underwater So, if such a connection was broken, at what point did the water act as a barrier to interaction rather than as a link?

If we are to address these issues the challenge now is to locate, recover, and analyze archaeological evidence from other environments that were sheltered from the destructive impact of rising sea level. To do this there is a need to understand the processes that reshaped the landscape in order to recreate locations where human activity might originally have been focused and where archaeological material is likely to be preserved and accessible to discovery. The work at Bouldnor Cliff has demonstrated this is possible and the material survives. By unravelling the formation processes of the Solent it has been shown that the palaeoenvironmental exposures are due to long-term geomorphological evolution, which is subject to extensive change. Understanding this may help us interpret comparable sites, a number of which are being identified in offshore geophysical datasets (Gaffney *et al.* 2007). Investigations at the site are in their infancy but the results are demonstrating the potential to open the door on this little understood phase of North European prehistory.

Conclusions

The data from Britain suggest that parity with continental European peoples was initially strong and that influences migrated between east and west before diminishing during the Late Mesolithic. This appears to be attributed

to environmental change, which led to increased forestation then sea-level rise. By *c*. 6000–5500 cal BC Britain had become an island and the expansive lands that once connected Britain to the continent were displaced permanently.

The process of inundation took several thousand years before a discernibly modern coastline was formed. During that time the resource-rich lowlands, which had been the foundation and springboard for British occupation and European coastal exploitation, steadily diminished as the landscape, and all who lived in it, were relentlessly inundated. The story, however, is far from complete as the evidence we need lies in land that is now many metres below the sea.

Archaeological sites and submerged landscapes, of which Bouldnor Cliff is an example, contain a wide range of well-preserved materials. They boast artefacts unlike any others found in contemporary terrestrial contexts demonstrating their potential to preserve rich and unique records of Mesolithic culture. Similar palaeoenvironmental deposits are now known to be prolific across the North European continental shelf. The discoveries at Bouldnor Cliff indicate that high levels of social and technical sophistication were achieved around the wetlands and estuaries in the period immediately preceding the final severance and formation of the North Sea. The archaeological record highlights the importance of this period to cultural divergence and human dispersal, while the European landmass took on its current shape. It is therefore apparent that drowned lands present a unique and incredibly significant archive that can offer a window into the lives of European people at a time of great change. To realize the full potential of the resource for both academic and management purposes there is a need to quantify the archaeological archive held within these submerged lands. It is not difficult to see how easily-accessible areas of stratified Mesolithic land like that found along Bouldnor Cliff present opportunities to study a drowned terrestrial landscape that has many parallels across Europe's shallow seas.

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Submarine Neolithic Stone Rows near Carnac (Morbihan), France: preliminary results from acoustic and underwater survey

Serge Cassen, Agnès Baltzer, André Lorin, Jérôme Fournier and Dominique Sellier

Carnac is internationally recognized as the best example of Neolithic rows of standing stones in western France. To better understand the significance of such alignments, an inventory of similar sites in the Carnac area was undertaken in 2003. Specifically, the alignment of 'Le Moulin', a site to the south of Carnac, which consists of five parallel lines of stelae inside the town of Saint-Pierre-Quiberon, was investigated. The extension of these stelae lines has been recognized to the east along the coast on an intertidal platform named Kerbougnec. The investigation aimed to assess whether this symbolic architecture continued offshore, which would give to this site a size comparable to that of Carnac. To answer to this question, several side-scan surveys have been conducted on the submerged part of the Kerbougnec platform, and these were validated by divers' observations on the identified acoustic anomalies. The concentration of acoustic anomalies forms a consistent extension of the architectural structure identified on land, and the orientation of the combined structure (on land and under the sea) is identical to the topological patterns recorded at Carnac.

Keywords: Neolithic, stelae, acoustic survey, underwater archaeology, western France

Introduction

The archaeology of the Neolithic rows of standing stones (straight or curvilinear, uninterrupted, or discontinuous) is a distinct feature of western France where such architecture is numerous and dense (Bailloud *et al*. 1995). Because of the lack of an appropriate conceptual framework, the interpretation of these sites is difficult, through both the lack of associated evidence and contextual information, and by confusion with persistence of ideas, opinions, and clichés developed from the beginning of the nineteenth century. Carnac epitomizes the problem. In this specific coastal zone of Brittany (Fig. 9.1), one of the unresolved problems remains the extent of this archaeological site, which spreads over several kilometres. It is not known where exactly it begins or ends (Boujot and Pinet 2007).

The main objective of the current research is to create an inventory of sites similar to Carnac, which might help in the general interpretation of standing stone alignments. The discovery of a significant site submerged in the Bay of Quiberon, near Carnac, also provided an opportunity to test the hypothesis formulated by Boujot *et al*. (1995) and Cassen (2009a). In this chapter we present the preliminary results of two side-scan sonar surveys validated by diver surveys, and will focus on the methods used to record the monoliths under the sea.

Figure 9.1: Top: The study area in Brittany. Bottom: location of Carnac north of the Bay of Quiberon (coloured composition of a Landsat ETM image dated 16.04.2003; topography by IGN–Institut Géographique National, using BD ALTI digital elevation model)

The question

Since the beginning of the nineteenth century, Carnac has generally been interpreted as a 'temple' (Cambry 1805; Mohen 2000), a rather vague term that is too poorly defined to apply accurately to such a cryptic architectural structure. In the second half of the twentieth century research on astronomic alignments and pseudo-scientific metrology was conducted on a restored (up to 80%) monument to determine if Carnac functioned as a lunar–solar observatory, earlier proposed by Gaillard (1897) and Devoir (1917), and to establish the existence of a prehistoric megalithic 'yard' (Thom 1955; Thom and Thom 1978). The result was to make obsolete any conclusion founded on such measurements, essentially based on alignments between imprecise points, and thus likely to fit to any geometric situation.

We suggest that the 'verticalization' of a monolithic object (a stele in this case) at the beginning of the Neolithic period may be regarded as a symbolic threshold between two dimensions, two spaces, two worlds, as a doorway-stele or a doorstep-stele. Furthermore, according to the definition of the anthropological concept of limit, the repetition of these stelae in a given space gives the impression of raising a barrier to prevent any intrusions, physical or virtual. We further propose the hypothesis that these stone rows acted as a 'cognitive barrier' (Cassen 2009a). They should be considered as a mineral fence that could stop, impede, or filter movement or passage. In this way, it is fundamental to define the topographical position and location of those rows (Cassen 2009b). We have been researching other sites, similar to Carnac, to develop a model that could help answer these questions.

At Saint-Pierre-Quiberon the alignment of Le Moulin (several parallel lines of stelae – Fig. 9.2), was restored in the nineteenth century, and constitutes a small, preserved archaeological site inside a modern housing development. The opportunity to follow the extension of these lines of stelae on the intertidal platform called Kerbougnec (or Kerbourgnec, but originally *Kerbonnec* in Breton) was a success, and groups of stelae were first mapped on the tidal flat by Cassen and Vaquero Lastre in 2003. Naturally, the question was raised, does this symbolic architecture continue under the modern sea level, which would confer to this site a size and importance similar to that of Carnac?

Figure 9.2: Two pictures of the high part of Le Moulin Neolithic stone rows (Photos: Z. Le Rouzic 1908, S. Cassen 2002)

The exploration of the Kerbougnec site (Quiberon Bay)

Graphically recorded and georeferenced in 2002 by DGPS (Differential Global Positioning System: Cassen and Vaquero Lastres 2003), the monoliths discovered on the rocky platform of Kerbougnec appear to be organized in parallel rows in the sectors that are most protected from swell and wave action (in comparison to the high-energy environment of the 'Côte sauvage' on the west part of the peninsula).

At the eastern base of the biggest block of a broken granite slab (Grande Stèle no. 1), a buried axe-head of Alpine jadeitite was discovered in 2003 (Fig. 9.3; petrographic determination by M. Errera, of the Agence Nationale de Recherche sponsored 'Programme Jade', directed by Pierre Pétrequin). This axe-head is a curiosity because of the distant provenance of the rock (Monte Viso, Italy). It is, however, not exceptional as four similar specimens – apparently non-functional axes – have been discovered at the site of the Petit Rohu, *c*. 1000 m further to the south. These polished blades seem to have been symbolically powerful objects rather than everyday tools. The presence of these emblematic objects in Kerbougnec confirmed the importance of this underwater site and encouraged us to extend our exploration toward the open sea.

Side-scan sonar surveys

The difficulty of prospecting in a marine environment with our usual archaeological methods encouraged us to collaborate with geographers and geologists. The terrestrial part of the archaeological and geomorphological survey was made on the rocky intertidal platform

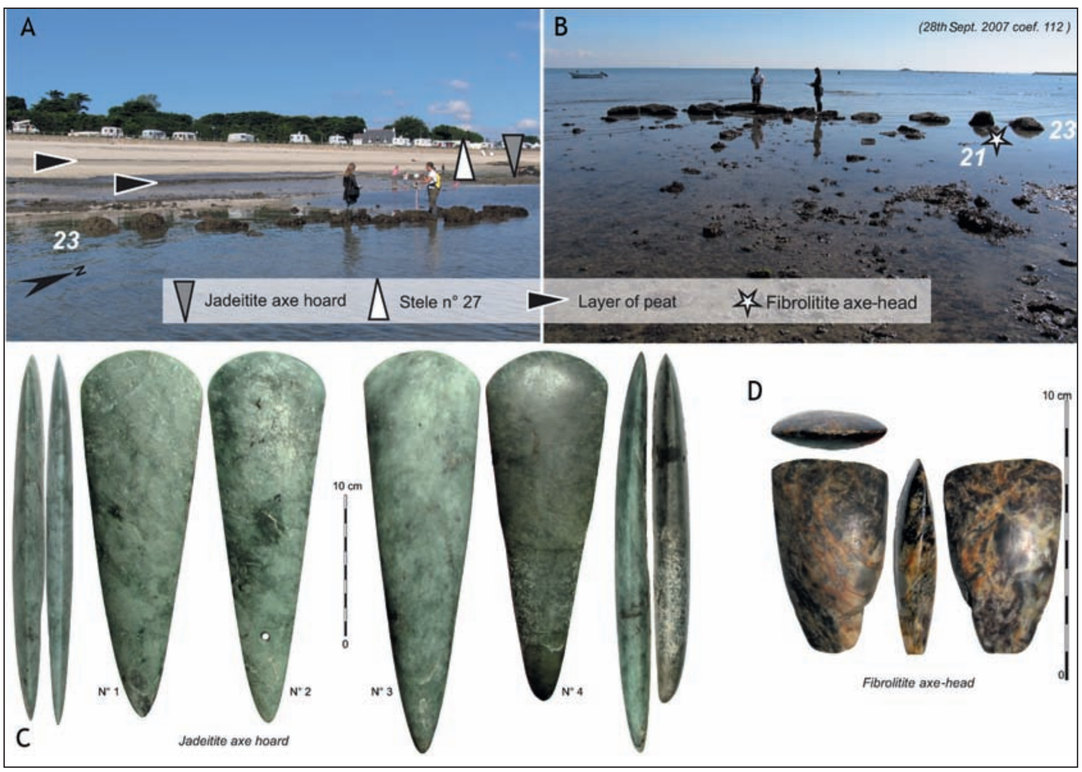


Figure 9.3: A–B Row of stelae discovered at low tide on the intertidal platform of Le Rohu, between Quiberon and Saint-Pierre-Quiberon. C–D Polished axe-heads found near the stelae at the positions marked '23' and '21' (After Cassen et al. *2010)*

during very low tides by traditional terrestrial and shallow water survey methods. For the marine part (2–10 m water depth), a geophysical survey of the possible submerged architecture was performed using side-scan sonar and diver observations.

The side-scan sonar is an acoustic geophysical instrument that, typically, is towed in the water behind the survey vessel. The method is based on recording echoes of an acoustic wave issued artificially and reflected by the different interfaces (Hobbs *et al*. 1994), the seafloor, and the boundaries between sedimentary layers. The results of a side-scan sonar survey are a map or image of the seafloor acoustic properties that can be interpreted for different objects on the seafloor or different seafloor types. The signal frequency determines the image resolution: the higher the frequency, the higher the resolution. From the side-scan image features such as dunes, sand waves, ripples, and rocky outcrops are readily identified (Augris *et al*. 1996). With the sonar towed *c*. 5–10 m above the seafloor an image (a band) 50–100 m wide on each side of the sonar can typically be recorded. The acquisition of several juxtaposed bands allows the realization of a 'sonar mosaic', which constitutes a very precise picture (with a resolution of *c*. 20 cm) of the seafloor. The resulting acoustic map can be geographically referenced (Bonnot-Courtois *et al*. 2005; Ehrhold *et al*. 2007, 2008; Fournier *et al*. 2009) to allow interpretation of different acoustic facies. Isis Sonar software and a Trimble Pathfinder Pro XRS GPS positioning system were used for data acquisition. To build mosaics we employed Isis Sonar and DELPH Seabed Mapping Software. Two sonars have been tested on the site:

- an Edgetech 272 TD was used with a frequency of 100 kHz. It is characterized by a maximum signal penetration of 1 cm into the sediment and a horizontal resolution of 30 cm. This sonar was used for initial reconnaissance to provide wide coverage profiles up to 200 m wide;
- a dual-channel SH1 (devised by Sture Hultqvist) was used with a frequency of 500 kHz allowing a horizontal resolution of about 10 cm. This system is commonly used in the exploration of wrecks (Cazenave de la Roche 2009) and allowed us to acquire two smaller 'mosaics' with profiles 25 m wide on each side.

In processing the data, the first step was to recognize the different types of acoustic anomalies that could indicate the presence of monoliths beneath shallow coastal waters. Potentially there is a risk of misinterpretation between monoliths and objects such as concrete blocks that served as moorings for yachts and are now covered by oysters and seaweed (cf. Atallah *et al*. 2005). The second step was to confirm the archaeological or autochthonous nature of these anomalies by diving.

Results from the acoustic surveys

The methodology proposed for the study, and in particular the ability to recognize the stelae as significant archaeological features was tested on the site of 'Le Petit Rohu', situated in the south of Kerbougnec (Fig. 9.3). This site revealed an extraordinary find in 2007: four polished axes made in Alpine jadeitite recovered within a submerged alignment of 26 monoliths, at 3.5 m below MSL (Cassen *et al*. 2008). Figure 9.4 shows the position of the sonar track acquired on this structure. The survey yielded sonar records of variable quality, as shown in Figure 9.5 for record Mos028bis. For each discrete anomaly identified from the sonar record, a corresponding anomaly was mapped by the archaeologists with DGPS (Cassen *et al*. 2008). The DGPS records were obtained during periods of very low tide (for a complete plan of the architecture, see Cassen *et al*. 2010). The sonar image (Fig. 9.5) clearly shows the group of fallen stelae (dimensions around 1 m), in spite of their relative burial in the sandy gravel seafloor.

At the site of Kerbougnec (further north), several of the sonar records acquired in 2009 also reveal a continuation of the monoliths recorded in 2002 onto the tidal flat (Fig. 9.6). In this area, the bathymetry already gives an idea of the ancient topography of the site before its invasion by the sea – a gently elevated platform. One can easily distinguish the details of the rocky platform under the sea on the photograph, as the site is characterized by an unusually high transparency of the water.

A number of profiles were acquired with the SH1 sonar between the buoy of L'Ours de Kerbougnec ('The Bear', which in this case refers to a reef or shallow water area) and the rocky intertidal platform exposed at low tide. Figure 9.7 shows the acoustic anomalies (marked by arrows) on a homogeneous sedimentary floor and the rocky platform (top, left) on which it is difficult to distinguish naturally deposited granite blocks from prehistoric monoliths placed on this

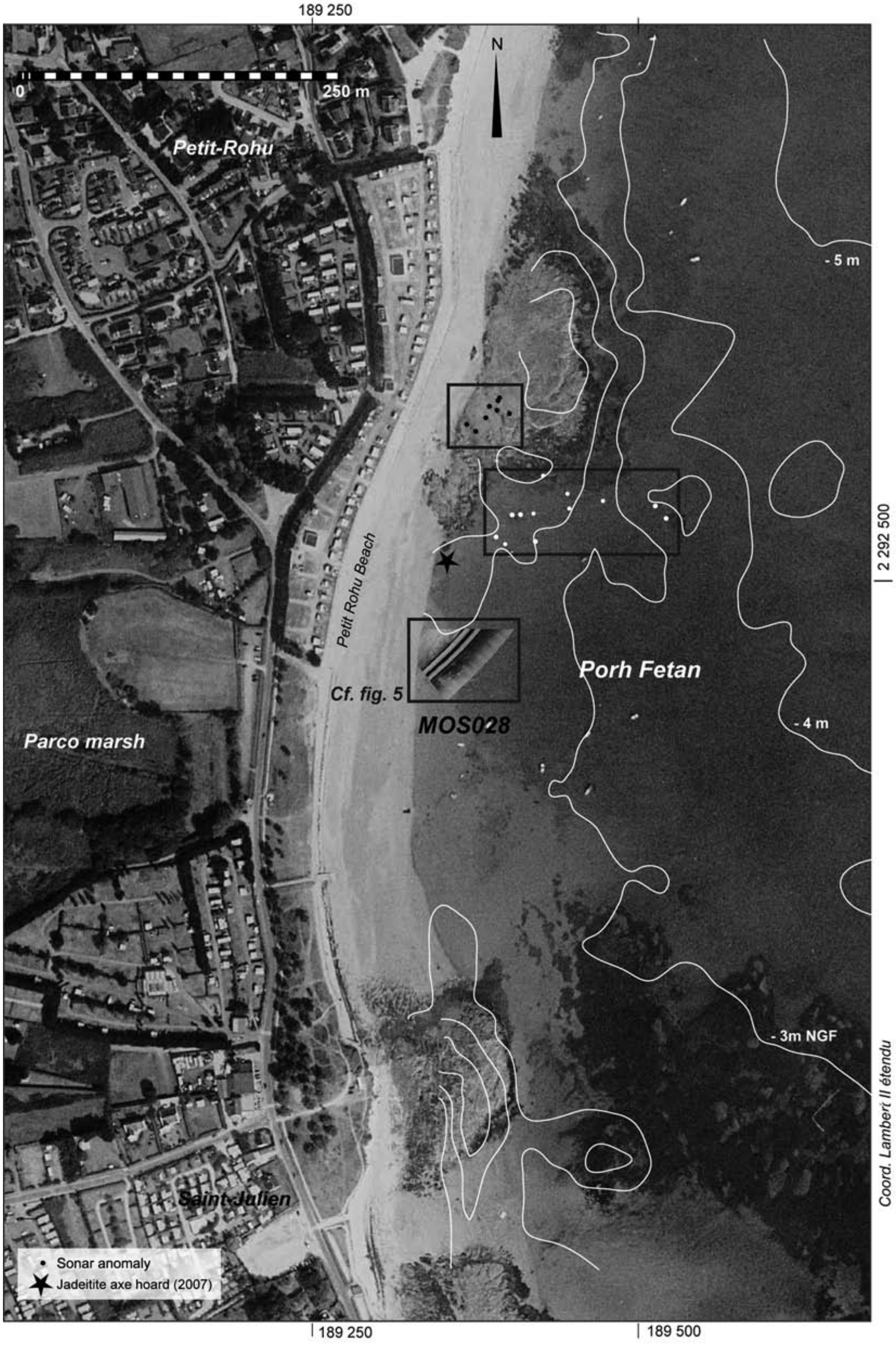


Figure 9.4: Petit Rohu. Location of the sonogram Mos028 above the Neolithic stone row, the positions of the monoliths detected by side-scan sonar, and the position of the polished axe deposit (Photo: IGN 2000)

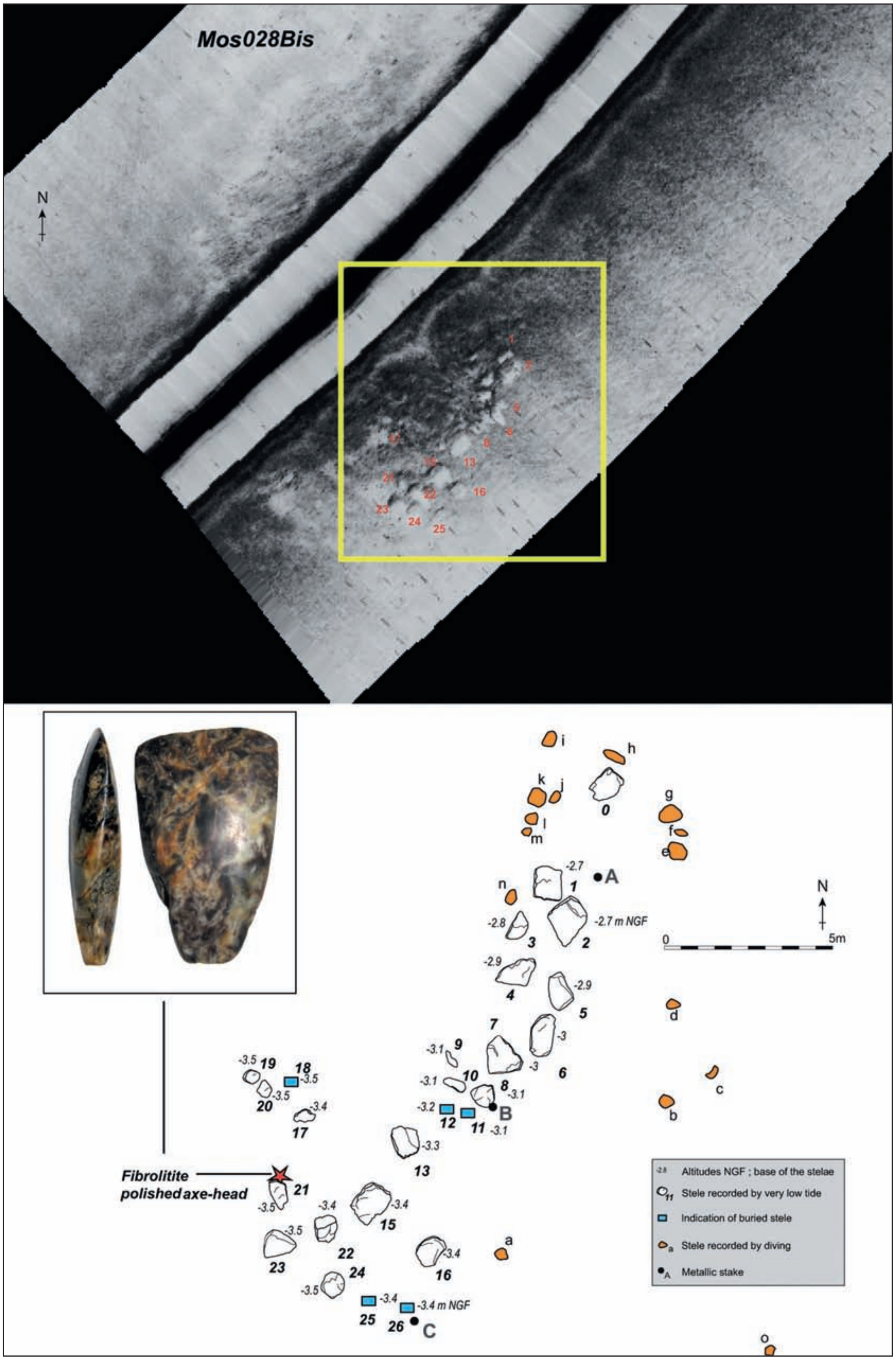


Figure 9.5: Petit Rohu. Comparison of the archaeological plan of the Neolithic stone row (After Cassen et al. *2010) and the side-scan sonar image of the structure (freq. 500 kHz)*

Figure 9.6: Kerbougnec. Side-scan sonogram mosaic between the rocky intertidal platform and the Ours shoal (Photo: IGN 2000)

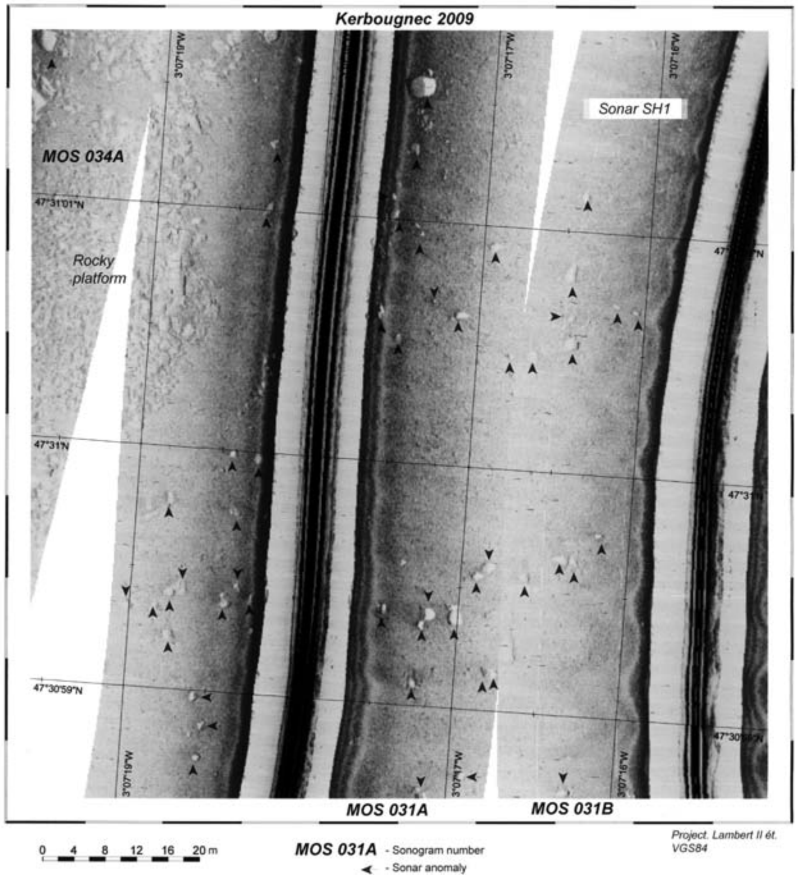


Figure 9.7: Kerbougnec. Zoom on sonograms Mos034A, Mos031A and Mos031B. Localization of the anomalies

substrate. Figure 9.8 synthesizes the anomalies extracted from six sonar records. There is an absence of features to both the north and south (for 100 m) from the area linking the beach with the reef of Kerbougnec.

The combined approach undertaken at this site reveals the performance of each side-scan sonar system. The highest frequency was very helpful for discerning blocks of 1–2 m length, and sometimes down to 0.5 m, upstanding by 0.5–1 m on the textured sandy floor and by only 0.2 m on a relatively homogeneous bottom. However, when flora and fauna cover the blocks on the rocky platform, the detection of acoustic anomalies is more challenging. Among all the sonar records, ten sites were chosen because of their quality in terms of resolution, repetition, and concordance of anomalies. From these, a preliminary (but not exhaustive) list of anomalies was selected for diving targets.

Results from the diving surveys

Surveys by divers were conducted in order to identify the nature of the acoustic anomalies. In this way it was shown that the majority of the anomalies correspond to granite monoliths. Their location on a sandy gravel seafloor was the first indication of their allochthonous origin. The divers conducted excavations around the base of each of the stones, to check that they were not connected with the subjacent substrate. Subsequent removal of seaweed, shells, etc., from a dozen of the blocks allowed us to observe the diversity of the monoliths' surfaces. On some of them, sharp edges have been noticed (Fig. 9.9D). Others have blunted edges belonging to ancient surfaces of the outcrop. If some marks indicate

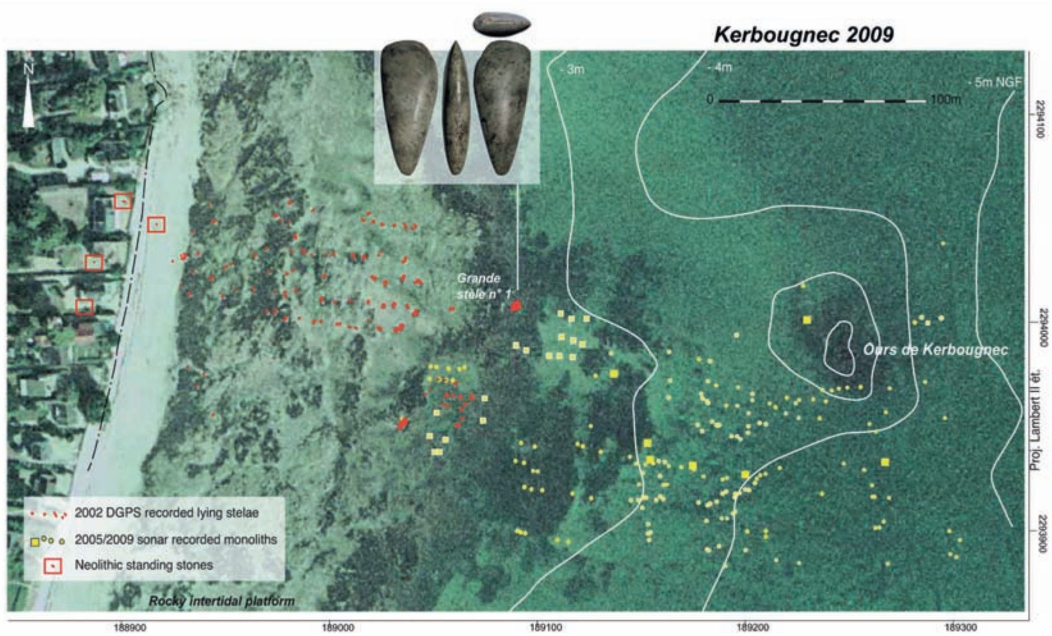
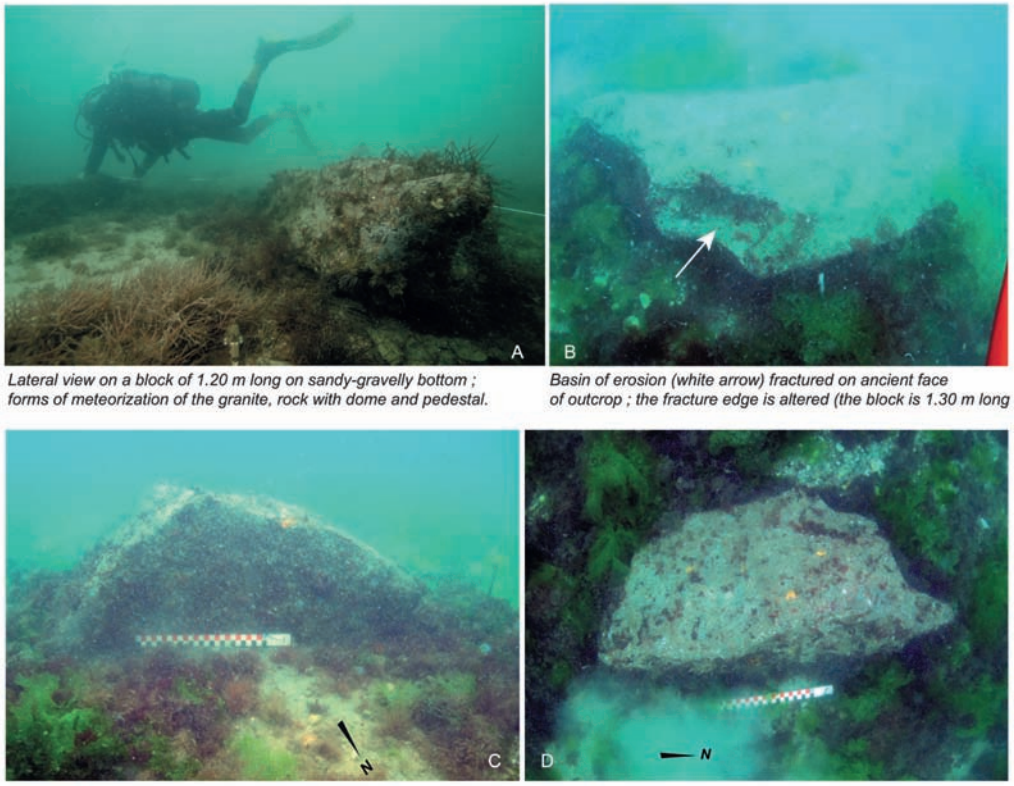


Figure 9.8: Kerbougnec. Synthesis between Neolithic monoliths recorded by DGPS on the rocky intertidal platform (left) and the anomalies recorded by side-scan sonar (right). Inset: the jadeite polished axe discovered at the base of Grande Stèle no. 1 (After Cassen et al. *2010)*



Lateral view on a block of 1.20 m long on sandy-gravelly bottom ; forms of meteorization of the granite, rock with dome and pedestal.

Basin of erosion (white arrow) fractured on ancient face of outcrop ; the fracture edge is altered (the block is 1.30 m long

Monolith K11, north section, on sandy-gravelly bottom ; sharp edges testifying an extraction.

Monolith K10 on sandy-gravelly bottom ; north extremity truncated (probable base of the stele) ; the edge of the fracture is still sharp.

Figure 9.9: Kerbougnec. Variations in the surface condition of the monoliths recorded, and forms of weathering of the granite (Photos: T. Abiven and A. Lorin)

the original extraction face from the substrate (the usual forms of weathering of the granite), the sharp, angular section of the monolith sometimes indicates a secondary position on the floor (Fig. 9.9C); in other words, extraction and displacement. The questions surrounding these features remained focused on the anthropogenic nature of the observed phenomena. Therefore, our main effort is concerned with surfaces that are consistent with typical forms of weathering of granite described by geomorphologists (Fig. 9.9B – face of extraction uppermost, sharp edges; Fig. 9.9A – rock with an older weathering pattern known as 'dome' and 'pedestal'), and comparable to the Neolithic standing stones of Carnac used as a reference (Sellier 1995, 1997). After validation by divers, several arguments can be made to assert the anthropogenic character of these features:

1. In spite of the obvious disorganization of the original architectonic structure owing to the force of the ocean, a regular pattern can be drawn in the plan at Kerbougnec, which shows straight and curvilinear alignments of granite stones.
2. The observation of the slab surfaces allows us to conclude that the majority of the stelae were extracted from a substrate different from the surface on which they presently stand. These blocks are also marked with forms of weathering of the granite attesting to the fracture of some of them and confirming an extraction from an outcrop before the sea invaded the area. These fractures, testifying to the movements of the blocks, could be explained by erosion and disruption caused by the ocean (Fichaut and Suanez 2006). However, such an explanation would be very difficult to defend as the blocks are situated in a protected area inside Quiberon Bay (Stephan 2009). Moreover, the concentration of anomalies forms a consistent extension of the already confirmed architectural structure, and does not continue to the north or the south, supporting the interpretation.
3. Regarding the formation of the features we note an observable change of direction in Kerbougnec (Fig. 9.10): two main lines, comprising around 30 monoliths, appear to bend toward the southern base of the natural outcrop known as L'Ours, following the curves of the underwater relief (3 m and 4 m below MSL). This change of axis is comparable to a similar phenomenon noticed on the submarine

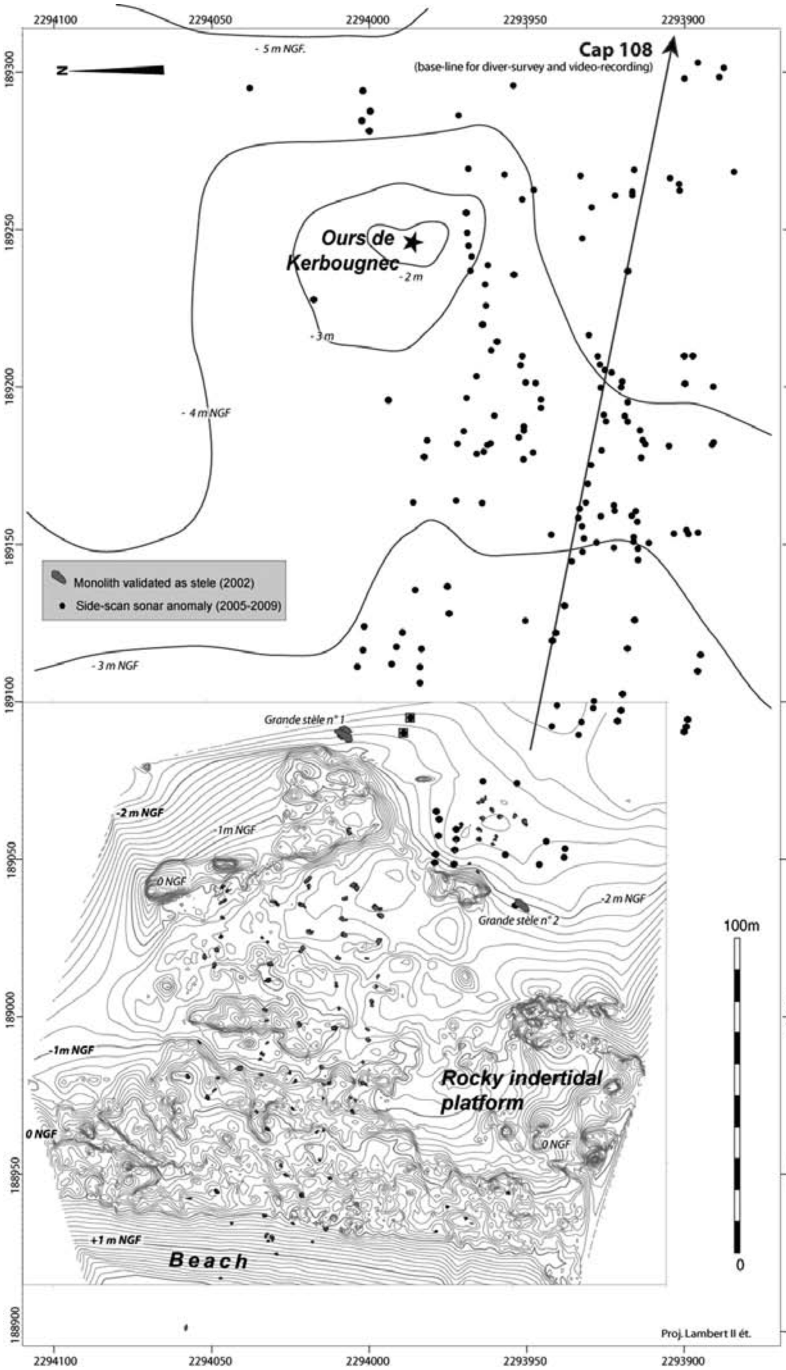


Figure 9.10: Kerbougnec. Lower part of Le Moulin/ Kerbougnec stone rows; synthesis of the anomalies detected on the sandy-gravel seafloor (the intertidal platform after Cassen and Vaquero Lastres 2003)

Neolithic stone row at Kerdual (La Trinité-sur-Mer), which is also centred on a natural rock outcrop (Cassen and Vaquero Lastres 2003; Cassen 2009b).

4. Finally, the direction of the structure is identical to the pattern noticed in Carnac, from Menec to Le Petit Menec, through Kermario, Manio, and Kerlescan, not in terms of strict topographical rules, or astronomic situation, but topological pattern which prevents movement in a given space (see Cassen 2009a).

Conclusion

This chapter has focused on the use of side-scan sonar to identify prehistoric monoliths in a marine context, in water depths of 2–5 m below MSL. During the research programme (2005–2009), two different side-scan sonar systems were tested with distinct frequencies (100 and 500 kHz). The instruments proved to be complementary and both useful for this type of fieldwork. For the identification of discrete targets the highest frequency sonar (500 kHz) is best suited, whereas the lower frequency sonar is most useful for site contextualization. On both sites, exceptional archaeological objects (polished axe-heads made from Alpine jadeitite and Iberian fibrolitite) confirm the age of these architectural structures as *c.* 4500 cal BC. The resulting maps of the structures showed the direction of stelae alignment to be identical to the pattern observed at Carnac, from Menec to Le Petit Menec, through Kermario, Manio, and Kerlescan in terms of topological pattern, a feature that prevents movement in a given space. We therefore suggest that such Neolithic architectural features be described as a 'barrier of stelae'.

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10

The Middle Palaeolithic Underwater Site of La Mondrée, Normandy, France

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During the 1970s, at a depth of c. *20 m, the La Mondrée site at Fermanville, Normandy yielded a large lithic assemblage of about 2500 artefacts and an equid tooth, associated with organic deposits attributable to the Middle Palaeolithic. The pollen spectra from a core taken near the site suggest the occupation dates to MIS 5. Reassessing this site within the framework of a Collective Research Project (PCR) on* Les Premiers Hommes en Normandie *has enabled us to go beyond the technological analysis of the artefacts from the 1970–1971 excavations, and to organize reconnaissance dives to investigate the morphology of the base of the Biéroc cliff where the prehistoric occupation was located, and to take sediment samples (by coring and grab sampling) in order to define the site's environment by sedimentological and palynological analysis. Exploration of test zones in 2002 revealed* in situ *occupation horizons that included a concentration of knapping waste.*

Keywords: Middle Palaeolithic, underwater archaeology, Normandy, La Mondrée

Introduction

La Mondrée (east of Cherbourg harbour) is one of a series of sites brought to light by coastal erosion since the 1970s, which point to the existence of an almost continuous scatter of Palaeolithic occupation evidence along the North-Cotentin coast between La Hague and Val de Saire. Investigations have revealed structured settlement areas with apparently artificial stone arrangements and hearths, which, in spite of the absence of bone due to soil acidity (except at Le Rozel), enable us to consider the occupations from a palaeoethnographic point of view (Cliquet 1994). The research has included geomorphological, palaeoenvironmental and geochronological studies (undertaken by the Centre de Géomorphologie of the CNRS at Caen, the CNRS/CEA at Gif-sur-Yvette, and the Universities of Oxford and Montreal), which have contributed to a better understanding of the Pleistocene littoral formations and eustatic variations attributable to the last two glacial–interglacial cycles (Coutard *et al.* 1981; Lautridou 1985, 1988; Clet-Pellerin 1988; Coutard *et al.* 2006). It is now possible to construct a chronological framework for these occupations based on chronometric dating (Cliquet *et al.* 2003; Coutard and Cliquet 2005).

The study of terrestrial cover sediments (loess, head [periglacial deposits], and palaeosols) and organic deposits overlying the beaches allows the correlation of marine levels with the 'Nordic' (as opposed to 'Alpine') chronology formations (Coutard *et al.* 1981; Lautridou 1985) and

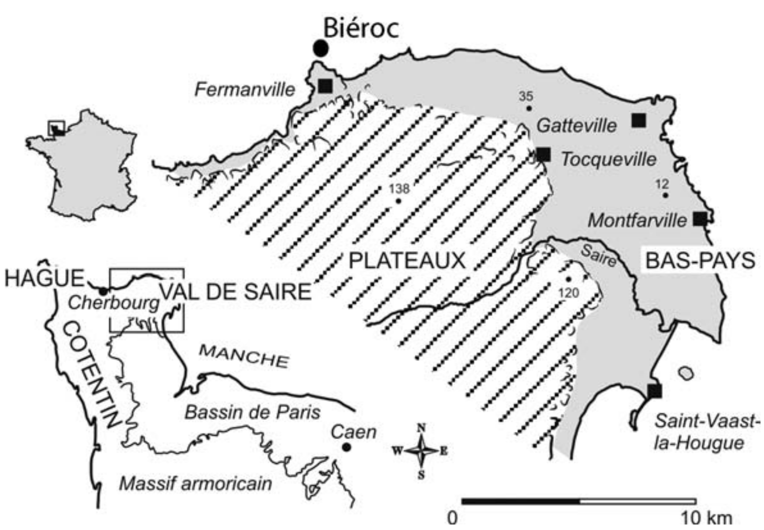
isotopic stages (Lautridou 1988; Van Vliet-Lanoë 1988).

Work undertaken over the last few years in Normandy, as part of Collective Research Project (PCR) *Les Premiers Hommes en Normandie*, is designed to investigate the general geomorphological context of the Palaeolithic occupation. The objectives include: establishing a precise chronostratigraphic framework based on absolute dating, providing more detailed pedosedimentary and environmental contexts for each site, establishing the characteristics of population movements on the basis of lithic assemblage studies and site function, and understanding the relationship between human occupations and the physical environment (Coutard 2003; Lautridou and Cliquet 2006; Cliquet and Lautridou 2009; Cliquet and Ghesquière 2010). The La Mondrée site has been studied in this context.

Location of the site and summary of previous research

The site of La Mondrée is situated near Val de Saire, to the east of Cherbourg, in the north of the Cotentin Peninsula, France (Fig. 10.1). The site lies at *c.* 20 m below sea level, at the foot of the east face of a palaeocliff, on the rocky islets known as the Biéroc, off the headland of Cap Lévi. Discovered in 1970 by Jean Allix, the site was investigated in 1970 under the direction of Frédéric Scuvée (1970, 1972), and the excavation report was published as a monograph (Scuvée and Véragué 1988). This was followed by a series of investigations aimed at documenting the site in more detail.

Figure 10.1: Location of the Val de Saire and the Biéroc–La Mondrée site (After Coutard and Cliquet 2005)



Human occupation was indicated by the presence of numerous worked flints and a poorly preserved equid tooth associated with Quaternary deposits. According to Scuvée's plans (Scuvée and Véragué 1988), the following sedimentary sequence was observed through coring: superficial deposits of shelly sand, gravel, and pebbles (modern); a layer of sandy mud averaging 80 cm thick; an eroded silty peat layer; and a basal layer of mud (Fig. 10.2). The lithic industry was apparently found in the lower two layers. The calcareous mud accounts for the preservation of an equid premolar found *in situ*, and a deer long bone, less well preserved, collected from the surface – both identified by M.-F. Bonifay (Fig. 10.3). Since the initial excavation the site has been carefully monitored by Jean Allix who has collected two bone objects, along with other artefacts that, unfortunately, were recovered out of context. One of these finds has been recognized as an aurochs bone (Fig. 10.3).

Although the lithic assemblage recovered from La Mondrée was not initially available for direct study, consideration of the published monograph raised several questions regarding the attribution of the lithic assemblage to the Mousterian of Acheulian Tradition (MTA; Cliquet 1994). The report described a *chaîne opératoire* of predominantly Levallois flaking and the manufacture of bifacial pieces (Scuvée and Véragué 1988). The very existence of the latter was called into question, on the one hand, because of the apparent lack of characteristic debitage and, on the other, because of the inexplicit illustrations of the so-called 'bifaces' in the monograph. This uncertainty led to the view (Cliquet 1994) that the assemblage could not be attributed to the MTA, and was more likely to belong to the Denticulate Mousterian, with a dominance of notched flakes and denticulates, and a few scrapers. Subsequently, access to the artefacts and re-examination of Scuvée's collections provided the opportunity to carry out a detailed typo-technological study of the La Mondrée assemblage, within the context of a Master's thesis (Margot 1998). This study confirmed the absence of bifacial pieces as well as biface manufacturing flakes, and established the presence of a significant quantity of notched pieces and denticulates; this has confirmed the attribution to the Denticulate Mousterian.

Figure 10.2: J. Allix taking a sediment core in 1970 (Photo: J.-J. Meusy)

Complementary to Allix's site surveillance, a sediment core was taken under the guidance of P. Auffret (Laboratory of Marine Geology, University of Caen) at 20 m depth in Mondrée Bay, about a kilometre from Cotentin's northeastern coastline. This sample, which was taken in order to clarify the nature and depth of the sediments overlying bedrock, was not directly associated with the site observed by Scuvée. Analysis of the core revealed a succession of polleniferous sands (Clet-Pellerin 1988), which point to the existence of a shoreline that was regularly transgressed. Furthermore, the basal sands yielded shells that have been analyzed for amino acids (by S. Occhietti and P. Pichet, Géotop, Uquam, Montréal), and these date the formation broadly to marine isotope stage (MIS) 5.

Finally, doctoral research by S. Coutard on the geomorphological, environmental, and chronostratigraphic context of the human occupations in the Val de Saire provided an opportunity for the members of the *Early Populations of Normandy Project* to reactivate the study of this site. Three diving seasons were conducted between 2000 and 2002 with the intention of further evaluating the site. These investigations included:

- ascertaining the state of preservation of the occupation level(s), and its/their horizontal extent (season 2000);
- elucidating the site stratigraphy (2000–2002), in particular the relationship between the cliff and the talus deposits at its base;
- sampling the sediments (by hand coring) for sedimentological and palynological analyses (2001 and 2002);
- precise determination of the position of the lithic material within the sedimentary sequence (2001 and 2002).

In addition, a high-resolution seismic survey was carried out in 2002, producing five profiles for La Mondrée Bay. Unfortunately, this survey had to be abandoned because of a heavy swell from a storm that occurred on the previous day. It was completed in 2003 by side-scan sonar.

General context of the occupation

The observation and investigation of the La Mondrée site since 1970 have enabled us to establish the general context of the Middle Palaeolithic occupation. Analysis of the wider territory ('habitat' in the broad sense) and the environmental setting have been approached by means of high-resolution seismic and side-scan sonar surveys (conducted by B. Tessier, F. Lelong, A. Baltzer, Y. Mear, and E. Poizot), the analysis of three sediment cores taken by J.-P. Auffret (Clet-Pellerin 1988) and by J. Olive (in 2001 and 2002), and Allix's observations of a ledge at 30 m below mean sea-level (MSL = Niveau Général Français, NGF). It is on this ledge that

Figure 10.3: Herbivore bones (Photo: D. Cliquet)

the slabs of raw material used by the Palaeolithic inhabitants are thought to occur, although this source of raw material was not located during the diving campaigns between 2000 and 2002.

Data relating to the wider landscape context

Elements provided by the five profiles obtained through the seismic survey of La Mondrée Bay enabled us to define four main seismic units (Fig. 10.4) described by Coutard (2003).

The image obtained of La Mondrée Bay is that of a granitic rock platform dipping toward the sea, with slight ridges (possibly old shingle beach ridges – visible in profiles 2, 3, and 6) and palaeochannels. Undated superficial deposits (unit C) occur in depressions. Traces of a Mesozoic sedimentary cover may be preserved on the granite in some places where the reflectors are particularly clear. The granite exhibits horizontal surfaces interpreted as abrasion platforms. These occur between 21 and 26 m below MSL in profile 5, whereas two levels separated by a talus slope (or escarpment) are evident at *c.* 17 m and 23 m below MSL in profile 3. An extensive lower platform is situated at *c.* 31 m below MSL.

These data complement observations of the inland context made by Coutard (2003). La Mondrée Bay is the outlet for the Vallée des Moulins, which extends inland for about 10 km toward the Triassic plateau. In 2000 a core taken at a distance of *c.* 500 m offshore from the river mouth revealed sediments up to 2.6 m thick. Behind an offshore sand bar known as Marais du Carat, another core encountered a marine deposit several metres thick. In some places, it was observed that the granite was very close to the surface, which raises questions regarding the position of the channel. Moreover, peat deposits have been observed on the foreshore to the east of the bay during spring tides. One must bear in mind that the survey profiles show a very complex situation in the bay. This survey demonstrates the need to carry out coring with an appropriate class of research vessel in order to identify the main seismic units.

Finally, the granitic and diaclased rocks of the Biéroc correspond to an ancient rocky bar, surrounded by the Eemian sea, oriented north-northwest to south-southeast, and measuring about 450 m long and a maximum of 9–10 m wide at a present-day altitude of 5.20 m above MSL. Taking into account the submerged portion,

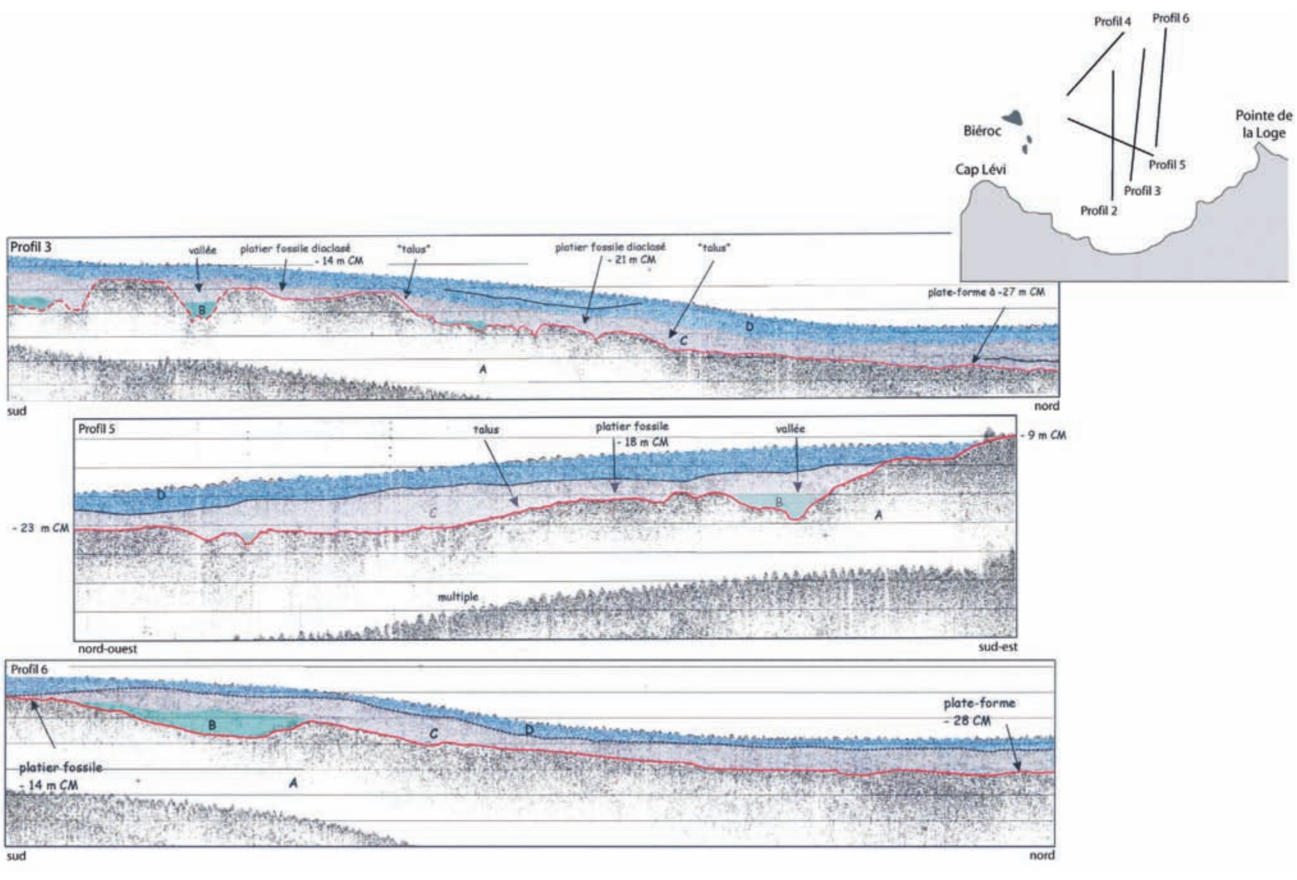


Figure 10.4: Seismic profiles reproduced and interpreted from Coutard (2003)

this bar is over 20 m high. It therefore constitutes a massif, i.e. a large elevated feature.

Palaeolithic remains occurred at the foot of this cliff, which has a slope of about 60°. Palaeolithic people occupied the foot of the cliff in front of a debris cone, a location that would have been sheltered from the prevailing wind. The occupation resembles those studied at Saint-Germain-des-Vaux–Port-Racine. These sites are a part of a large group of sites that made use of natural topographic features (shelter, cave, steep slope, rock, or doline) thus forming a natural boundary to the archaeological deposits. This is quite different from the large open living sites or workshop sites (Lautridou and Cliquet 2006; Cliquet and Lautridou 2009) identified on loess covered plateaux or wide, flat, valley bottoms, where occupations can extend over several hundreds of hectares (e.g. Saint-Brice-sous-Rânes; Cliquet *et al.* 2009).

Stratigraphy of the Palaeolithic occupation

The excavation undertaken by F. Scuvée in 1970 and the cores and samples taken from the site between 2000 and 2002 show a relatively homogeneous stratigraphy (Fig. 10.5). Below the surficial gravelly sand, there is *c.* 15–25 cm (up to 60 cm in places) of grey silty shelly sand, sometimes rich in organic matter (Coutard 2003; Coutard and Cliquet 2005).

The lithic industry occurs on this deposit. Underneath there is ochre-coloured shelly or azoic sand containing small pebbles at its base. Morphological analysis shows that the upper part of the sand is aeolized. Core P (taken in 2001) shows a thin layer of fine, silty sediment within this ochre-coloured sand at a depth of about 45 cm, from which was recovered a flint core. The presence of worked flint in these same sands at a similar depth in core G (also taken in 2001) raises several questions about the possible existence of a second occupation level and/or taphonomic processes that may have affected the upper occupation level. This question has yet to be resolved. It would be unreasonable to try to connect the stratigraphic sequence to the acoustic features of the available seismic profiles, as the boat used for the survey could not get near the rocks, and hence the seismic profiles were not acquired from the exact location of the site; moreover, observations made by divers are fragmented. It follows that additional cores corresponding to the seismic profiles must be obtained.

In the three cores (AM1, AM2, and AM3) pollen analysis was conducted on sediments (mainly sludgy grey surface sands) that are older than the human occupation. The relationship between the three cores is uncertain because we lack details of the precise location of core AM1, which was taken about a kilometre from the coastline. In this core, the association of Chenopodiaceae and ferns indicates the existence of a salt marsh zone that was regularly inundated by the sea, in a sedimentary context representing a phase of regression. The arboreal vegetation (the association of *Pinus*, *Quercus*, and *Corylus*) suggests the warm climate of an interstadial

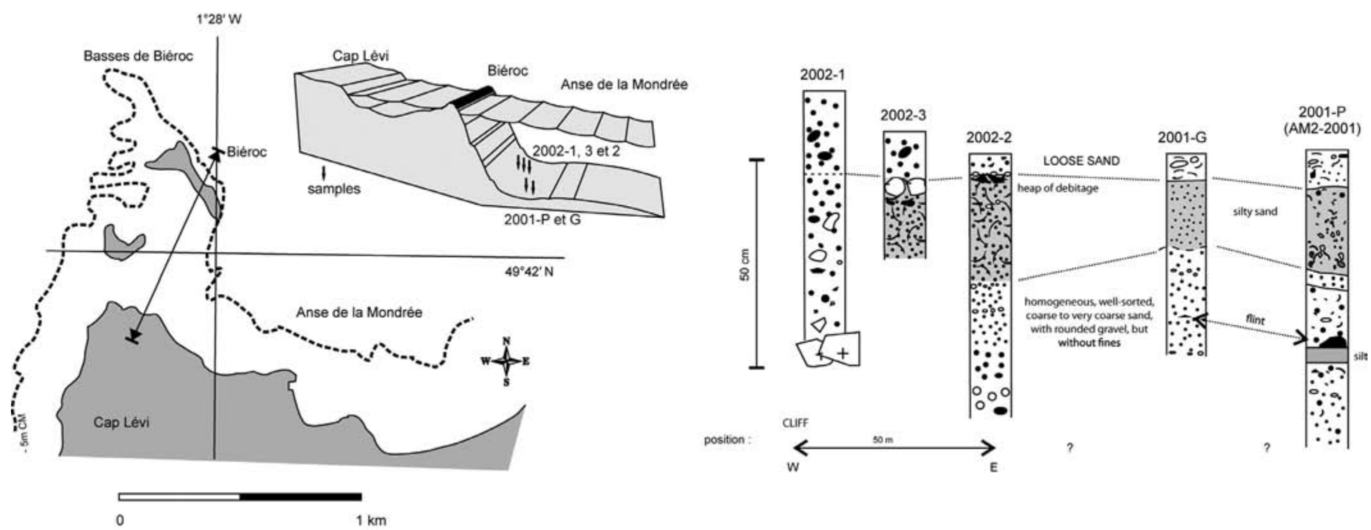


Figure 10.5: Location and stratigraphic sequence of the Biéroc–La Mondrée site (After Coutard and Cliquet 2005)

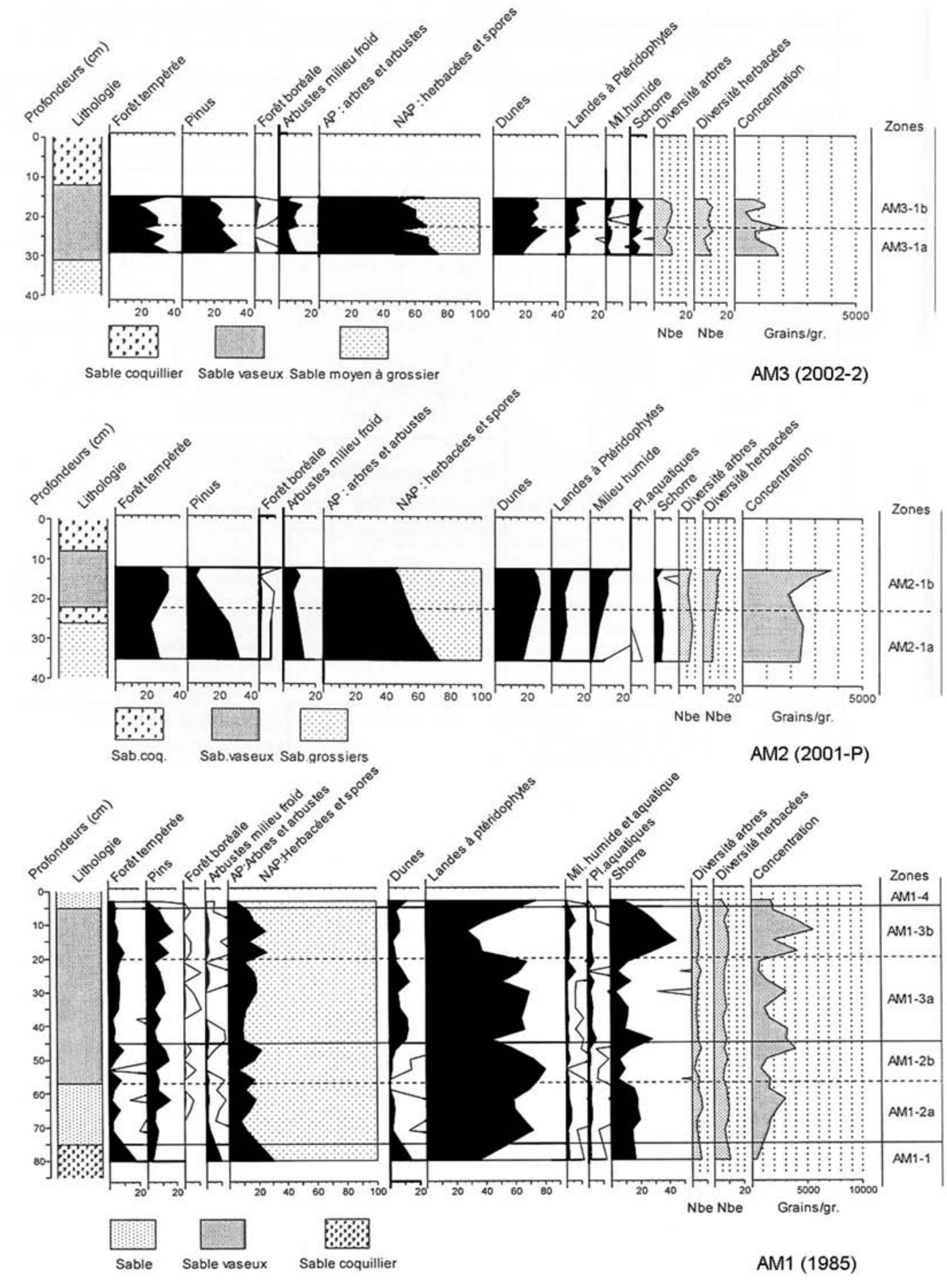


Figure 10.6: Pollen diagrams from the AM1 (1985), AM2 (2001-P) and AM3 (2002-2) cores (After Coutard 2003)

phase. The low proportions of *Carpinus* and *Abies*, rule out dating this level to the end of phase 5 (climatic optimum). Attribution to MIS 5c (Brørup Interstadial) seems more likely.

The other two cores (AM2 and AM3) were taken from the occupation site between 50 m and 100 m from the cliff. Core AM2 exhibits a pollen assemblage corresponding to freshwater marshes developing behind a sand bar. Pollen from trees growing on a freshwater marsh edge is more abundant than in core AM1, but the range of species remains the same. It would seem that the upper part of core AM1 (AM1-3) corresponds to samples from AM2 and AM3, which appear to present a similar vegetation sequence. Two possible explanations for these similarities are:

1. The sediments are contemporaneous, but AM1 was taken on the edge of the seashore in a marine environment, whereas AM2 and AM3 correspond to a continental environment behind a sand bar.
2. The AM2 and AM3 cores follow the shore succession – freshwater marshes in the course of a regressive cycle – and are thus earlier than the sediments in core AM1.

The first hypothesis seems more plausible because of the relatively high proportions of temperate forest trees found in AM2 and AM3, and because of the proximity to the shore attested by the predominance of fern spores and Chenopodiaceae in AM1. Indeed, if the regressive cycle were later, at the point when the shore was transforming into an inland marsh, the climate would have had to have cooled sufficiently to allow the replacement of the temperate forest by boreal forest.

Taking into account the depth at which the samples were taken, under *c.* 20 m of water, the sea level of this interstadial would have been *c.* 20 m below MSL, and could correspond to MIS 5a, dated to *c.* 70 ka BP (based on the simulation by Chappell and Shackleton [1986]).

Human occupation (the site *sensu stricto*)

According to Scuvée and Vérague (1988) the layer of lithics appeared to lie within a depression measuring *c.* 180 × 50 m, adjacent to the talus at the foot of the palaeocliff. The excavation in 1970 consisted mainly of collecting artefacts from the depression (around 370 pieces) without any precise recording of the find locations. Artefacts were collected from four regions on the seabed, covering an area of >1300 m² (denoted PI, PII, PIII, and SV on the site plan; cf. Scuvée and Vérague 1988). The collection (*c.* 2500 lithics in total) consists almost exclusively of pieces measuring >4 cm. According to Scuvée and Vérague (1988) the artefacts were found concentrated in a 'relatively small area'. They noted the 'apparent absence of micro-flakes and small pieces of knapping debris' (Scuvée and Vérague 1988: 27), an observation confirmed by the recent diving expeditions.

Nature of the site

The Biéroc rocks are the continuation above sea level of a submarine cliff at the foot of which prehistoric people settled during the Last Glaciation. Prior to the 2000–2002 investigations, evidence of human occupation was confined to the presence of numerous lithic artefacts and three bone fragments, identified as horse and, probably, aurochs. The precise nature of the site, that is the number of occupation events and the site function (whether it was hunting camp, workshop, etc.) remained to be determined. This was one of the objectives of our research project on the earliest inhabitants of Normandy. One of the three test zones explored revealed a concentration of debitage products, some of which could be refitted. Indeed, seven cortical or partially corticated pieces illustrate the cortex removal sequence starting from a natural block (Figs 10.7 and 10.9). However, the nature of the collecting process precludes the 'isolation' of knapping waste that was produced in a single operation. A hearth-like feature was evident at the foot of the cliff in sectors 1 and 5 at Port Racine. On this site domestic spaces were characterized by alignments of stone blocks that seem to delimit internal spaces (shelters). Knapping areas could be discerned from the distribution of debitage. A pit and several hearths were also identified.

Remains illustrating a similar form of spatial organization have been identified on several sites at La Hague and the Val de Saire. They occur in sheltered positions at the Pointe de la Masse at Gatteville-le-Phare, at Montfarville quarry and blockhaus (bunker) at The Fort of Saint-Vaast-la-Hougue, and at the foot of the wall of Le Rozel rockshelter at Port-Racine. There is also evidence of occupation remains in crevices and sea-cut fissures or depressions at Gélétan,

Figure 10.7: Refitting cortex removal flakes (test zone 2002-2) (Photo: D. Cliquet)

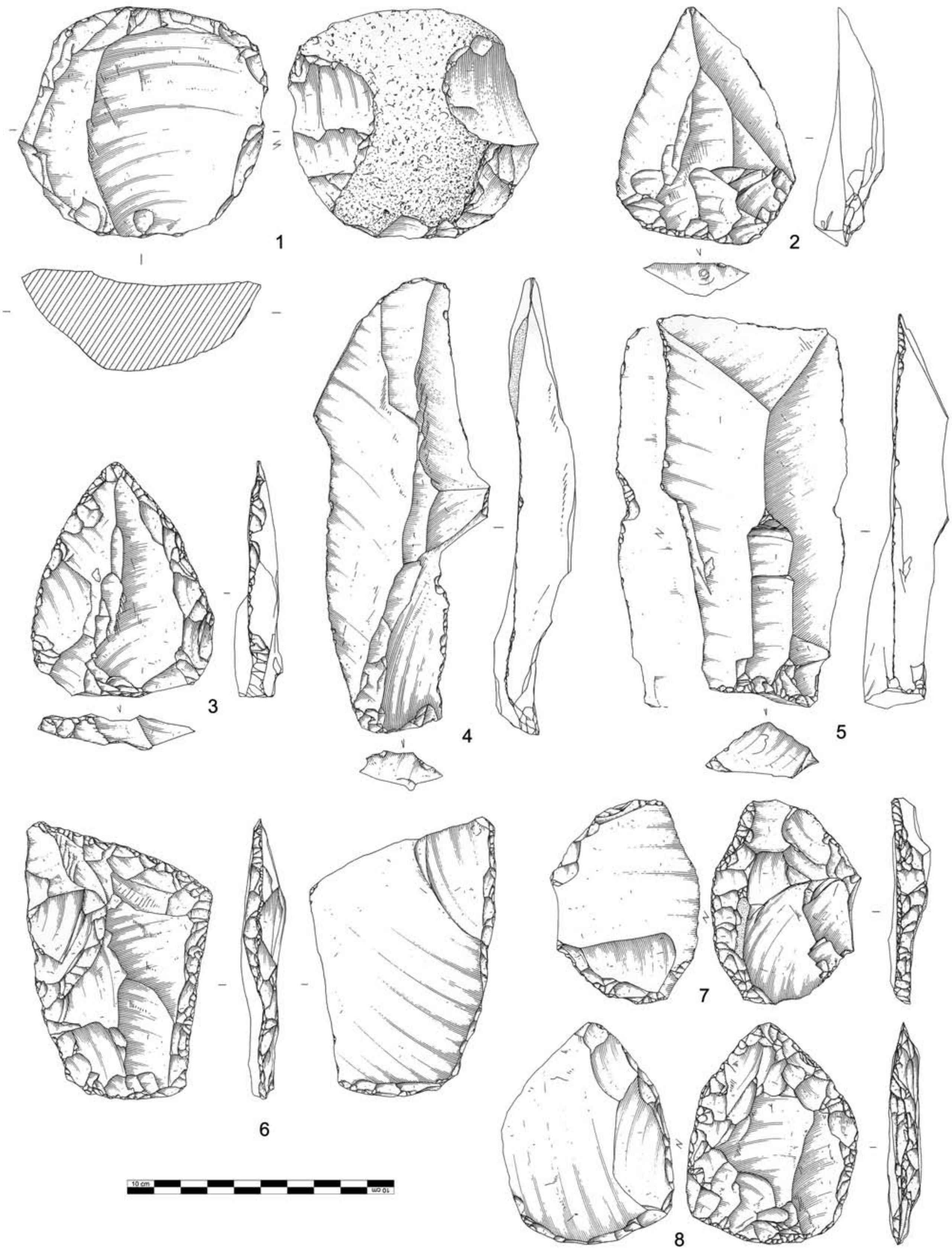


Figure 10.8: Lithic industry from the excavation by F. Scuvée 1970 (Drawings: P. Alix)

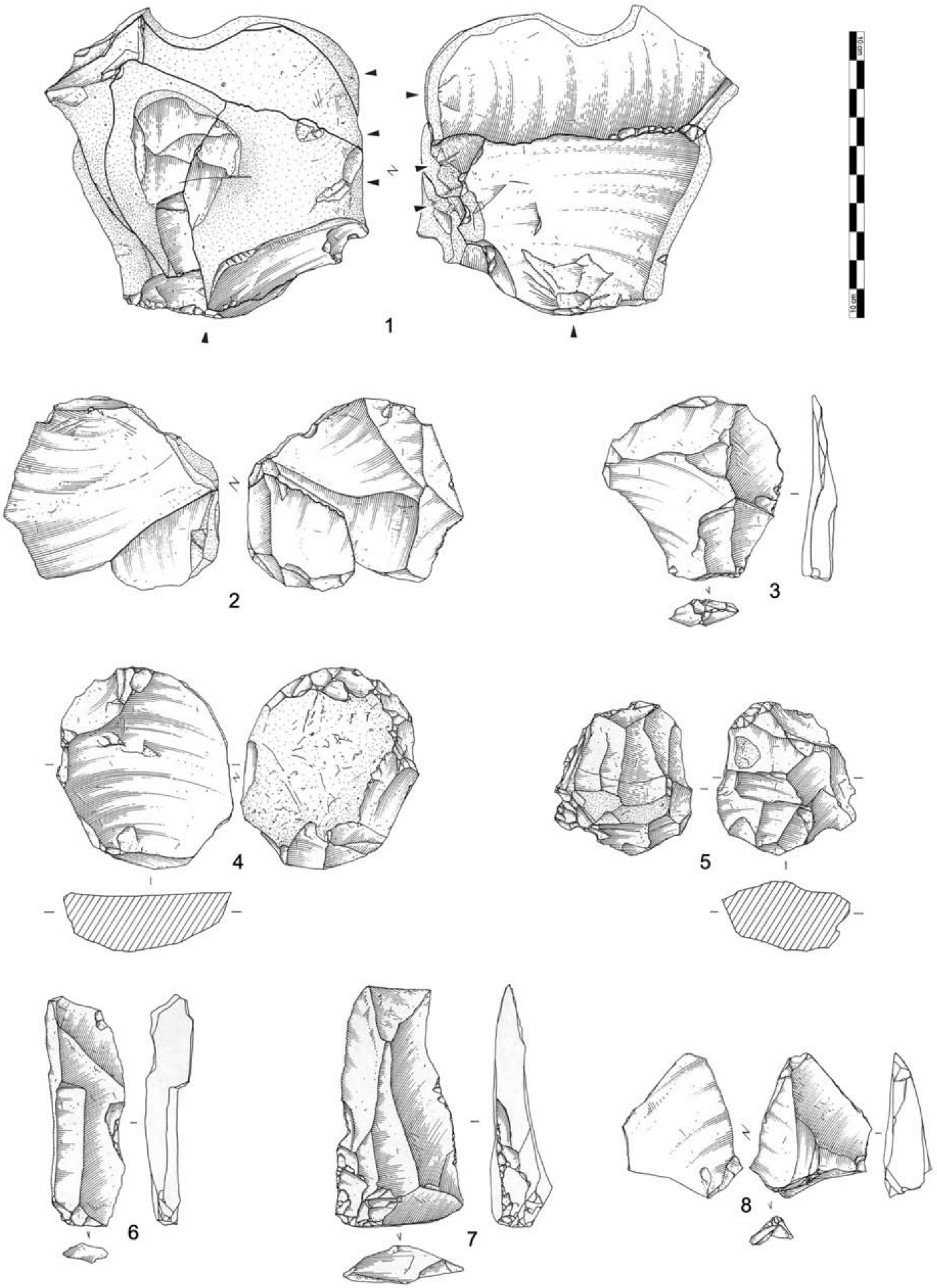


Figure 10.9: Lithic industry from test zones 2002 (Drawings: P. Alix)

Gouberville, and Port-Pignot (Coutard and Cliquet 2005; Lautridou and Cliquet 2006; Cliquet and Lautridou 2009).

Characterization of the lithic industry

Re-analysis of the artefacts collected in 1970–1971

Scuvée and Vérague (1988) described the technique of flake production as predominantly Levallois, with bifacial tools also evident. Cliquet (1992) questioned the existence of bifaces, and his interpretation was supported by Margot's (1998) study (Tables 10.1–2).

Contribution of the diving expeditions in 2000–2002

The diving expeditions in 2000 confirmed the presence of 'fresh' finds lying directly on the seabed (Fig. 10.9). Around 40 artefacts were collected and then compared to the finds from Scuvée's excavations. The lithics were similar in form to those recovered by Scuvée. Levallois production was by far the dominant technique and was oriented toward the production of large flakes that could have served as blanks for tools (scrapers and Clactonian notches, in this case); the 'Kombewa' method, in which large flakes were struck from larger flakes, is also attested (Table 10.3).

Table 10.1: Scuvée's assemblage from the 1970–1971 excavation (Margot 1998)

Type	Type	N
Amorphous core	*Nucléus informes*	9
Core on a flake	*Nucléus sur éclat*	67
Flake – core	*Eclat – nucléus*	18
Discoidal core	*Nucléus discoïdes*	31
Core with a non-Levallois surface	*Nucléus gérant une surface non Levallois*	10
Core exploiting the natural convexities of a block (Levallois reduced)	*Nucléus gérant une surface et exploitant les convexités naturelles du bloc (levallois reduced)*	12
Recurrent Levallois core	*Nucléus Levallois récurrents*	99
Preferential Levallois core	*Nucléus Levallois à éclat préférentiel*	21
Core with two removal surfaces	*Nucléus à deux faces de débitage*	21
Core fragment	*Fragment de nucléus*	55
Sub-total	***Sous-total***	**343**
Complete Levallois flakes	*Eclats Levallois entiers*	502
Flakes from discoidal cores	*Eclats issus de mode de débitage discoïde*	106
Kombewa flakes	*Eclats kombéwa*	18
Non-Levallois flakes	*Eclats issus de mode de débitage non levallois*	985
Fragments of removals	*Fragments d'enlèvements*	371
Angular debris	*Cassons*	34
Debris	*Débris*	29
Unidentifiable rolled pieces	*Pièces roulées non identifiables*	11
Heat spall	*Enlèvement chauffé*	1
Total	***Total***	**2057**
Total pieces examined	***Total du mobilier étudié***	**2400**

Table 10.4: Artefacts collected in 2001

Type	Type	N
Levallois core	*Nucleus levallois*	2
Tested «branch-shaped» block of flint	*Bloc de silex «branchu» testé*	1
Flakes with cortex (one of which is very worn)	*Eclats de décorticage (dont 1 très émoussé)*	4
Secondary Levallois surface preparation flake	*Eclat de préparation de surface levallois partiellement cortical*	1
Levallois flakes and fragment (1)	*Eclats levallois et fragment (1)*	3
Kombewa flake	*Eclat kombéwa*	1
Unspecified worn cortical flake	*Eclat indéterminé cortical émoussé*	1
Debris	*Débris*	1
Total	***Total***	**14**

Table 10.2: Tools from Scuvée's assemblage from the 1970–1971 excavation (Margot 1998)

Type	Type	N
Levallois flake	*Eclat levallois*	502
Levallois point	*Pointe levallois*	5
Pseudo-Levallois point	*Pointe pseudo-levallois*	5
Mousterian point	*Pointe moustérienne*	4
Single straight side-scraper	*Racloir simple droit*	11
Single convex side-scraper	*Racloir simple convexe*	22
Single concave side-scraper	*Racloir simple concave*	13
Double straight/convex side-scraper	*Racloir double droit-convexe*	2
Double straight/concave side-scraper	*Racloir double droit-concave*	1
Double convex side-scraper	*Racloir double biconvexe*	3
Double concave/convex side-scraper	*Racloir double concave-convexe*	2
Convergent convex side-scraper	*Racloir convergent convexe*	2
Offset side-scraper	*Racloir déjeté*	12
Straight transverse side-scraper	*Racloir transversal droit*	6
Convex transverse side-scraper	*Racloir transversal convexe*	6
Concave transverse side-scraper	*Racloir transversal concave*	2
Side-scraper with alternate retouch	*Racloir à retouches alternes*	1
Typical end-scraper	*Grattoir typique*	2
Atypical side-scraper	*Grattoir atypique*	5
Typical burin	*Burins typiques*	1
Atypical piercer	*Perçoir atypique*	1
Naturally backed knife	*Couteau à dos naturel*	6
Notch	*Encoche*	139
Denticulate	*Denticulé*	40
Bec burinant alterne	*Bec burinant alterne*	4
Piece retouched on the ventral surface	*Retouches sur face plane*	10
Abruptly retouched piece – thick	*Retouches abruptes épaisses*	18
Abruptly retouched piece – thin	*Retouches abruptes minces*	39
Rabot	*Rabot*	5
Total	***Total***	**869**

Type	Type	N
Parallel unidirectional recurrent Levallois core	*Nucleus levallois récurrent unipolaire parallèle*	1
Centripetal recurrent Levallois core	*Nucleus levallois récurrent centripète*	1
Two-sided unidirectional Levallois core	*Nucleus levallois unipolaire sur les deux faces*	1
Corticated flakes	*Eclats corticaux*	2
Partially corticated flakes	*Eclats partiellement corticaux*	9
Flakes with traces of cortex	*Eclats avec restes corticaux*	2
Indeterminate flakes	*Eclats indéterminés*	3
Preparation flakes with a plain platform	*Eclats d'aménagement de plan de frappe*	1
Preparation flakes with partially corticated surface	*Eclats d'aménagement de surface partiellement corticaux*	1
Special preparation flake	*Eclat d'aménagement*	1
Unidirectional convergent Levallois flakes	*Eclats levallois (gestion unipolaire convergente)*	1
Unidirectional parallel Levallois flakes	*Eclats levallois (gestion unipolaire parallèle)*	4
Opposed bidirectional Levallois flakes	*Eclats levallois (gestion bipolaire opposée)*	1
Orthogonal bidirectional Levallois flakes	*Eclats levallois (gestion bipolaire orthogonale)*	2
Centripetal Levallois flakes	*Eclats levallois (gestion centripète)*	2
Plunging Levallois flakes	*Eclats levallois débordants*	2
Partially corticated flakes produced by parallel recurrent unidirectional core reduction	*Eclats de gestion unipolaire récurrente parallèle partiellement corticaux*	1
Partially corticated flakes produced by centripetal unidirectional core reduction	*Eclats de gestion unipolaire centripète partiellement corticaux*	1
Kombewa flake	*Eclat kombéwa*	1
Total	***Total***	**37**

Table 10.3: Artefacts collected in 2000

			Sondage 1					Sondage 2						Sondage 3	
Type	Type	'Fresh' series	'Worn/rolled' series		Total sondage 1		'Fresh' series	'Worn/rolled' series				'Fresh' series	'Worn' series		Total sondage 3
Core	*Nucleus de gestion de surface*							1					1		1
Centripetally worked core	*Nucléus de gestion de surface centripète*						1								
Orthogonally worked core	*Nucléus de gestion de surface orthogonal*						1								
Levallois core	*Nucléus levallois*						1								
Lineal unidirectional Levallois core	*Nucléus levallois de gestion unipolaire linéale*	1													
Unidirectional recurrent Levallois core	*Nucléus levallois de gestion récurrente unipolaire*											1			1
Opposed bidirectional recurrent Levallois core	*Nucléus levallois de gestion récurrente bipolaire opposée*						1								
Orthogonal bidirectional Levallois core	*Nucléus levallois de gestion bipolaire orthogonale*	1													
Centripetal recurrent Levallois core	*Nucléus levallois de gestion récurrente centripète*	2					2								
Flake core utilizing the natural convexities of the blank	*Nucléus sur éclat utilisant les convexités naturelles du support*						1					1			1
Branch-shaped flint nodule	*Apophyse en silex branchu*	1													
Primary flake	*Eclat de décorticage à face entièrement corticale*	4	2				6	1				3			3
Secondary flake with ≈ 75% cortex	*Eclat de décorticage à face aux trois quarts corticale*	3	1					1				1			1
Secondary flake with ≈ 50% cortex	*Eclat de décorticage à face semi corticale*	4	1				10					9			9
Secondary flake with ≈ 25% cortex	*Eclat de décorticage à face au quart corticale*											1			1
Blade-like flake with ≈ 75% cortex	*Eclat de décorticage laminaire à face aux trois quarts corticale*							1					1		1
Blade-like flake with ≈ 50% cortex	*Eclat de décorticage laminaire à face à demie corticale*							1					1		1
Blade-like flake with ≈ 33% cortex	*Eclat de préparation de surface de débitage, à face 1/3 corticale*	4													
Preparation flake with lateral convexity, naturally backed	*Eclat d'aménagement de convexité latérale, dos cortical*	1					1								
Convex preparation flake	*Eclat d'aménagement de convexité*											5			5
Surface preparation flake	*Eclat d'aménagement de surface de débitage*						2								
Secondary Levallois surface preparation flake	*Eclat d'aménagement de surface levallois partiellement cortical*											1			1
Levallois surface preparation flake	*Eclat d'aménagement de surface levallois*											1			1
Secondary surface flake	*Eclat de gestion de surface partiellement cortical*						2					1			1
Secondary surface flake, burned	*Eclat de gestion de surface partiellement cortical chauffé*											1			1
Secondary unidirectional surface flake	*Eclat de gestion de surface unipolaire partiellement cortical*											2			2
Secondary orthogonal surface flake	*Eclat de gestion de surface orthogonale partiellement cortical*											2			2

Secondary centripetal surface flake	*Eclat de gestion de surface centripète partiellement cortical*											2			2
Surface flake	*Eclat de gestion de surface*	4	2				2					2			2
Surface flake from discoidal core	*Eclat de gestion de surface (issu d'un nucléus discoïde)*						2								
Unidirectional preferential surface flake	*Eclat de gestion de surface unipolaire*											4			4
Opposed bidirectional surface flake	*Eclat de gestion de surface bipolaire opposée*											1			1
Centripetal surface flake	*Eclat de gestion de surface centripète*											2			2
Unidirectional preferential Levallois flake	*Eclat levallois préférentiel de gestion unipolaire*											1			1
Unidirectional Levallois flake	*Eclat levallois de gestion unipolaire*	1					2					5			5
Opposed bidirectional Levallois flake	*Eclat levallois de gestion bipolaire opposée*	1					1					8			8
Orthogonal bidirectional Levallois flake	*Eclat levallois de gestion bipolaire orthogonale*							1				7			7
Centripetal Levallois flake	*Eclat levallois de gestion centripète*						4					2			2
Levallois flake	*Eclat levallois*						3					4			4
Secondary Levallois flake	*Eclat levallois partiellement cortical*						3					3			3
Plunging Levallois flake	*Eclat levallois débordant*											1			1
Plunging flake	*Eclat débordant*											2			2
Crested rejuvenation flake	*Eclat de réaménagement avec crête*											1			1
Blade-like Levallois flake	*Eclat levallois laminaire*						2					4			4
'Levallois blade'	*'Lame levallois'*											1			1
Blade-like preparation flake with lateral convexity	*Eclat laminaire d'aménagement de convexité latérale, à dos cortical*											4			4
Blade-like flake	*Eclat laminaire*						2	1				2	1		3
Secondary blade-like flake	*Eclat laminaire partiellement cortical*						1								
Pseudo-Levallois flake	*Eclat pseudo-levallois*						2					4			4
Pseudo-Levallois point	*Pointe pseudo-levallois*						1								
Kombewa flake	*Eclat kombéwa*	1					2					1			1
Secondary indeterminate flake	*Eclat indéterminé partiellement cortical*	2	1				6	1				8	1		9
Indeterminate flake	*Eclat indéterminé*	4					5	1				3			3
Preparation flake	*Eclat de façonnage ?*		1												
Debris	*Débris*	3	9									3			3
Debris – secondary	*Débris partiellement cortical*						3	1				1	1		2
Small pieces < 30 mm	*Petits éléments < 30 mm*	4					1					1			1
Broken pebble	*Galet cassé*		1												
Flaked pebble	*Galet taillé*							1							
Frost-shattered pebble	*Galet gélivé*		1												
Pebble fragment	*Fragment de galet*		2												
Hammerstone	*Percuteur*	1													
Quartz flake with cortex	*Eclat en quartz à face corticale*											1			1
Quartz preparation flake	*Eclat d'aménagement en quartz*	1													
Total	**Total**	**43**	**21**				**70**	**11**					**6**		**113**

Table 10.5: Artefacts collected in 2002 from test zones 1, 2, and 3

In 2001 piston coring techniques were used for this operation, yielding 14 objects, 13 of which were recovered from the seabed (Table 10.4). The other object, a 'branch-shaped' block of flint was found at the boundary between carbonated mud and sand. This piece possesses the same characteristics as those collected by Allix and Scuvée in 1970–1971 and the small assemblage found on the seabed in 2000. Nevertheless, the fact that some pieces were found on the seabed, while one was deeply embedded in the substrate, suggests the existence of at least two occupation levels.

In 2002 observations were made by means of a test excavation (the meticulous excavation of a zone 1.5 × 1.5 m by successive passes with an airlift). As in the 2000 and 2001 seasons, the diving in 2002 confirmed the presence of well-preserved lithics lying on the surface of the seabed and as stratified finds, often associated with a sandy deposit (in sample zones 1, 2, and 3; Table 10.5), and a grey mud level (in sample zones 1 and 2).

Adverse diving conditions (poor visibility and unstable sandy sediments and currents) prevented us from differentiating possible occupation levels. Artefacts collected in the test zones included some pieces moved by the sea; however, most of the material was found *in situ*. Although it is likely that two distinct contexts are represented, the typo-technological analysis relates to all of the artefacts collected since 1970. In the previous studies Levallois production was predominant, with a variety of debitage forms evident, e.g. undirectional, bidirectional, and centripetal. The desire to produce long flakes for further production is illustrated by artefacts from test zones 2 and 3. These include blade-like flakes obtained by shaping and preparing the face of the core, attesting to the use of the Levallois technique.

Figure 10.10: Core and large flakes of Cretaceous flint (Photo: D. Cliquet)

The raw materials used by the Palaeolithic inhabitants

The dimensions of the debitage pieces and the discarded cores (in some instances >30 cm long), suggest the use of a source of sizeable pieces of raw material, which is quite rare for the North-Cotentin lithic assemblages (Fig. 10.10).

Occupation of the ancient seashore and coastal plains provided Palaeolithic people with a supply of lithic raw materials in the shingle ridges along the littoral fringe. When settlement was on or close to the shingle ridges, marine regression and the 'continentalization' of the palaeoshorelines would induce people to travel further, up to several tens of kilometres, to reach alternative sources of raw materials (the nearshore raw material sources would be covered by dunes and steppe vegetation). As is the case for the 'loessic' sites in Normandy and for the eastern margins of the Norman Armorican Massif (where raw material, i.e. flint, is accessible in clays), flint was once again the favoured raw material.

Analysis of the La Mondrée artefacts (including nodule size and cortex) suggests supplies were obtained either from a chalk band recently exposed by regression/transgression processes and periglacial conditions, or from the clay-with-flints eroded during the colder periods of the early part of the Last Glaciation (Coutard and Cliquet 2005).

The outer (corticated) surfaces of a number of artefacts exhibit surface solution cavities comparable to those observed on nodules from the clay-with-flints. These corticated surfaces show no trace of wave erosion (e.g. 'nail' marks or impact marks). Some very big cores suggest the use of large slabs of flint, examples of which were apparently observed by J. Allix on a shelf at a depth of about 30 m. It was not possible to confirm these observations during the 2000–2002 diving expeditions. Finally, in the La Mondrée assemblage, the presence of two pieces made from vein quartz, one of which has been worked to form a side-scraper (Fig. 10.11), should be noted.

Figure 10.11: Scraper made from a flake of vein quartz

Except at the sites of Saint-Pierre-Eglise/Clitourps and Jardeheu at Digulleville, where local materials were used (e.g. Triassic conglomerate, quartz, and sandstone at Saint-Pierre; granite, aplite, diorite, and dolerite at Jardeheu), the use of substitute or complementary raw materials appears exceptional in the North-Cotentin, where human settlements occupy a headland position, thus always close to the shingle bars.

Use of rare granite, sandstone, quartz, and quartzite pebbles is illustrated at the Middle Pleistocene sites of Gouberville, Gélétan at Saint-Germain-des-Vaux, and Port-Pignot at Fermanville (Cliquet and Lautridou 2009), and on Late Pleistocene sites at The Fort at Saint-Vaast-la-Hougue (Cliquet and Lautridou 2005). The use of vein quartz is apparent at the Le Rozel rockshelter (Van Vliet-Lanoë *et al.* 2006).

The situation is quite different in the Norman-Breton gulf, where the shoreline is some distance from the human settlements. The prehistoric population resorted to certain substitute materials (e.g. sandstone, quartz, quartzite, and volcanic rocks). This is illustrated by the work of Monnier (1981) and Huet (2006) in Brittany, Callow in Jersey (Callow and Cornford 1986), and to a lesser extent by the observations of Pruvost (2006) on the Chausey archipelago. The use of local stones attests to raw material acquisition strategies adapted to environmental surroundings.

La Mondrée within the Middle Palaeolithic technocomplex of northwestern France

Although the La Mondrée lithic assemblage is distinguished by the size and nature of the raw materials used (large nodules and slabs of Cretaceous flint), and thus by the size of

Figure 10.12: Reconstruction of the environment at the time of the Middle Palaeolithic habitation (Drawing: L. Juhel)

the flakes knapped, it fits perfectly with the group of industries showing a tendency toward Levallois flake production and, to a lesser degree, the discoidal method. This production of flakes and long splinters can be found on some Cotentin Middle Palaeolithic sites at Gouberville, sometimes associated with bifacial pieces made from small slabs, as at Gélétan, or from a central mass (i.e. carved from a block, the 'nucleus' of which formed the tool) as at Fermanville-Port-Pignot, Digulleville, Jardeheu and Equeurdreville-La Saline, where the biface production concept is part of the Acheulian tradition. The Levallois technique appears equally well expressed in most of the Upper Pleistocene Cotentin sites, such as Le Rozel, Siouville, Tréauville, Port-Racine, Anse de Quéry at Montfarville, La Grosse Butte and Le Bruley at Fermanville, and The Fort at Saint-Vaast-la-Hougue (Coutard and Cliquet 2005).

Apart from the site of Pointe du Heu at Bretteville-en-Saire where there is an unusually high proportion of bifacial pieces (including 'Micoquian-type' bifaces) associated with the production of Levallois flakes, at other North-Cotentin sites like Querqueville-C.I.N., Montfarville-Blockhaus and Quarry, and La Pointe de Fouly at Réville, only a few bifacial pieces made on flakes and/or tabular fragments (e.g. 'pot-lid' flakes or small slabs) attest to the manufacture of bifacial tools (Coutard and Cliquet 2005).

The evidence currently available indicates that the MTA (Mousterian of Acheulean Tradition) is not represented in the Armorican massif. Rather, this region is characterized by a facies known as the 'Mousterian with bifacial tools', which on present evidence represents a late stage of the Middle Palaeolithic, overlapping in time and spatial distribution with the MTA to the southwest and the Central European Micoquian to the east (cf. Cliquet *et al.* 2009: fig. 10).

Conclusion and perspectives

Reappraisal of the Biéroc–La Mondrée site has enabled us to conduct a technological study of the artefacts recovered in 1970–1971, as well as the small collections obtained during diving campaigns between 2000 and 2002. The assemblage is part of a group distinguished by a high proportion of Levallois-type lithics, with the tool component comprising mainly notched pieces and, to a lesser extent, scrapers made on large flakes. The raw material acquisition strategies seem to be unique (because of the nature of the locally-available raw materials) characterized by the exploitation of large nodules and slabs of Cretaceous flint. These raw materials could either come from eroding clay-with-flints, dislocated by fluctuations of sea-level during the Pleistocene (and thus easily accessible during the Last Glaciation), or from carbonate rock formations, equally dislocated.

However, even after three years of diving, the full extent of the site remains unknown. The seabed is covered by shelly sand the thickness of which varies according to the presence of pebble zones, i.e. accumulations and spreads of marine shingle. Underneath the seabed sediments there is a finer deposit, which is grey and hard, probably the upper carbonated mud layer noted by Scuvée (Scuvée and Vérague 1988: 27). Although the environmental context has been determined, both in terms of the local ecology and the spatial extent of the occupation (with the discovery of a concentration of debitage probably related to a living area at the foot of the cliff), our investigations have not so far established whether there were one or two occupations, or the precise date. Nevertheless, the main occupation appears to have been associated with an intertidal zone at a time of marine regression.

Based on palynological data, the La Mondrée site has been attributed to MIS 5a (or, perhaps, 5c). As emphasized by Coutard (2003: 387) it 'corresponds to the uplift of the Val de Saire', so that only the glacial periods and their interstadials can be represented below sea level (Trenhail 2002). The platform observed in seismic surveys at 20 m depth may reflect a period of stabilization of sea level during MIS 5a (Chappell and Shackleton 1986; Lundberg and Ford 1994; Richards *et al.* 1994).

The palaeotopography of La Mondrée Bay has still to be determined in detail, in particular the nature of the fill of the depressions, the extent of the site, the possible presence of diachronic occupation levels and their state of preservation, requiring taphonomic and micromorphological observations. The occupation horizons could be dated by luminescence (TL and OSL) techniques. These investigations would require additional remote sensing (seismic or side-scan sonar survey) along with a series of geotechnical samples (cores) aimed at establishing the nature and depth of the sediments that currently overlie the granite bedrock of the bay.

Rather than conducting limited underwater excavations in difficult working conditions and poor visibility, risking further degradation of the site, it would be preferable to take a larger 'block sample' of the sediments in order to conduct chronostratigraphic and taphonomic analyses under 'laboratory' conditions, and facilitate OSL dating of the various units. It would help to aim for a general understanding instead of excavating unnecessarily, and seem appropriate to preserve what is left of this site. Future generations will doubtless have more sophisticated means of investigation than are currently employed.

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11

Investigating Submerged Archaeological Landscapes: a research strategy illustrated with case studies from Ireland and Newfoundland, Canada

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The Submerged Landscapes Archaeological Network *(SLAN) is an international, multidisciplinary research group investigating drowned prehistoric landscapes off the coasts of Ireland and Newfoundland. Both regions experienced lowered relative sea level (RSL) during their earliest colonization. The earliest Newfoundland archaeological sites are believed to be located on 6–9 ka cal BP shorelines now submerged in 10–30 m water depth, whereas along the north coast of Ireland, sea levels were lowered by 5–30 m during the earliest known Mesolithic (*c. *9.7 ka cal BP). Our objectives are to understand how these now-submerged environments facilitated the expansion of the first populations and how the evolving coastal landscape may have stimulated social change. We have developed a seven-stage research strategy to prospect for submerged sites that first attempts to reconstruct the palaeolandscape using various datasets including geophysical models of RSL change, high-resolution bathymetry, and sub-bottom profiles. The intention is to identify areas where the palaeolandscape is preserved and where features preferentially utilized by past humans are situated. Identified zones of high archaeological potential can subsequently be targeted for local site survey and testing. This paper will outline our research strategy and provide illustrated examples of current work.*

Keywords: sea-level change, submerged archaeological landscapes, colonization, Mesolithic, Ireland, Maritime Archaic, Newfoundland

Introduction

The past decade has seen renewed interest in the study of submerged prehistoric archaeology driven in part by accumulating evidence demonstrating the preservation of sites and landscapes underwater, a growing recognition of the potential importance of coastal environments for prehistoric subsistence and migration, and improvements in marine remote sensing technology, which make feasible underwater mapping and investigation at landscape scales (Bailey and Flemming 2008). While much of this interest is driven by a desire to address long-standing archaeological questions (e.g. the antiquity of marine/coastal adaptations), the effective and systematic investigation of submerged prehistoric landscapes arguably requires considerable interdisciplinary collaboration and partnerships with government and industry-led seabed mapping programmes.

An interdisciplinary approach is necessary because many of the requisite technologies and expertise come from non-archaeological disciplines, such as marine geology and oceanography. Recently, these technologies have been deployed successfully in submerged archaeological projects (e.g. Harff *et al.* 2005; Gaffney *et al.* 2007; Wessex Archaeology 2008).

Interdisciplinary approaches are also practical from a cost perspective. The involvement of multiple disciplines adds value to a given survey because the data can be collected once and then used many times by all interested parties (see for example Kostylev *et al.* [2001] and Todd [2005], which use the same dataset to produce habitat maps and study submerged dune development, respectively). Similarly, a vast quantity of seabed data are collected for commercial (e.g. oil and gas extraction and aggregate dredging), military, or navigational purposes and require close collaboration with government and industry in order to access them for archaeological research (Flemming 2004).

To facilitate such collaboration, the *Submerged Landscapes Archaeological Network* (SLAN) was created in 2005 (Bell *et al.* 2006). The network represents a consortium of researchers from universities and government agencies in Ireland and Newfoundland that builds on previous successful collaborations between Newfoundland and Irish marine industries and institutions. The ultimate goal of SLAN is to understand how the submerged coastal environments of the North Atlantic rim facilitated the expansion of its first peoples and how the evolving coastal landscape, marine resources, and climate may have stimulated social and cultural change.

To this end, SLAN has developed an interdisciplinary approach to the investigation of submerged archaeological landscapes. Our approach is explicitly landscape focused in that it aims to reconstruct the palaeolandscape using marine geophysical, geological, and palaeoenvironmental data, and then query this palaeolandscape to identify and sample areas of high archaeological potential. It is worth noting that this philosophy also underpins a number of other submerged landscape investigations (e.g. Fedje and Josenhans 2000; Gaffney *et al.* 2007). We believe that this approach gives the best chance of success in our study areas, where high-energy conditions dominate (see below) and preservation may be restricted to small pockets, making it essential to pinpoint locations with the greatest chance of finding archaeological material. In addition, accurate interpretation of existing archaeological sites, as well as future discoveries, requires them to be placed in an accurate palaeoenvironmental context. Thus, an understanding of the evolving palaeolandscape from an early stage gives a head start in this regard.

The goal of this paper is to first give a general overview of the research approach and second, illustrate its implementation with specific examples from projects in Newfoundland and Ireland. As research is still ongoing, the full strategy has not yet been completed and therefore the examples presented are preliminary conclusions primarily related to palaeolandscape reconstruction. Nonetheless, we aim to demonstrate that these have archaeological applicability in identifying submerged areas of high archaeological potential and providing the palaeolandscape setting crucial to addressing questions of past environmental change and human response.

Archaeological and environmental background

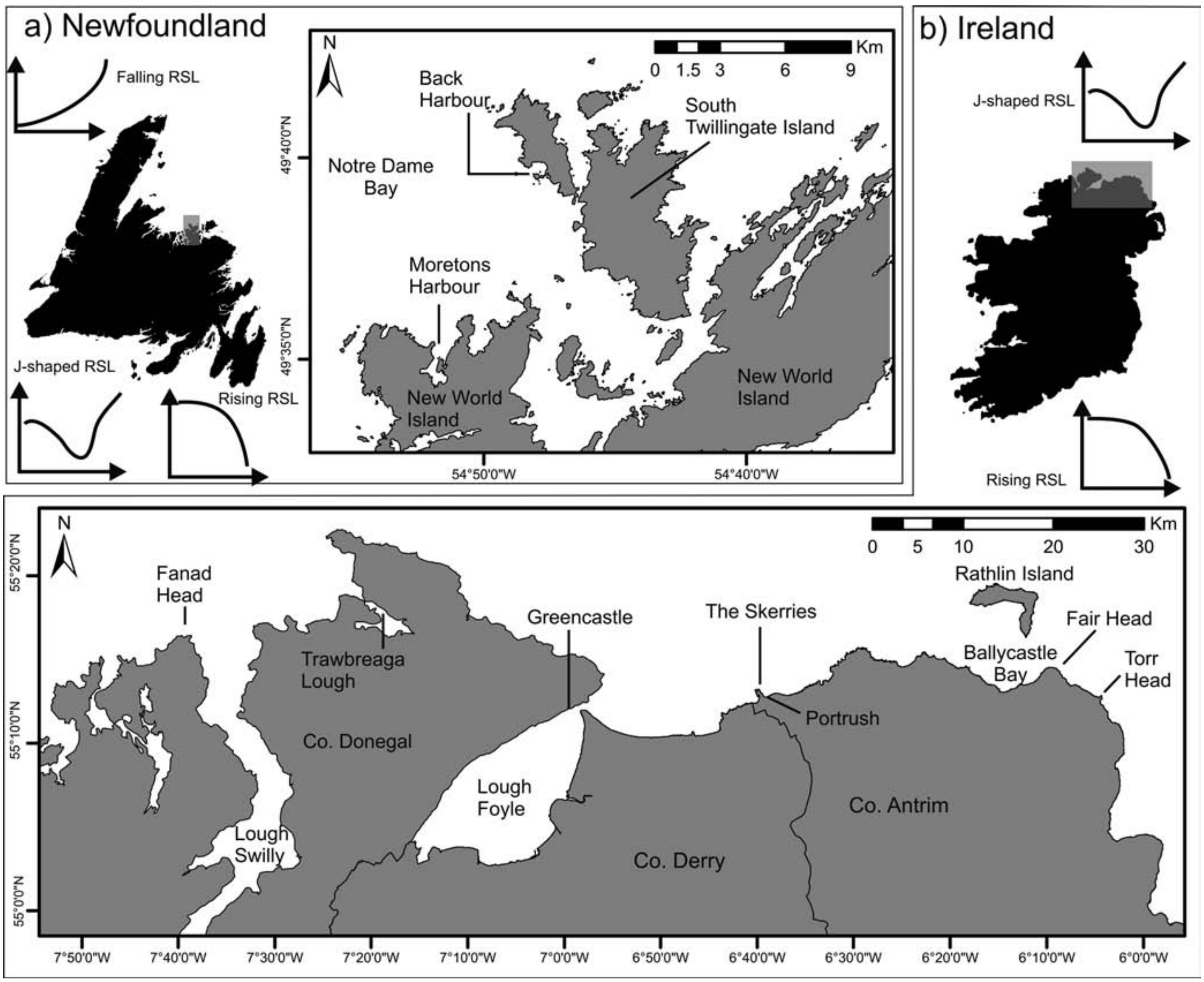
Although Newfoundland and Ireland are situated on opposite shores of the North Atlantic, they share similar archaeological and palaeoenvironmental contexts. Both were ice covered during the Last Glacial Maximum (*c.* 24–21 ka cal BP), with ice retreat beginning around 21 ka cal BP and complete deglaciation from *c.* 15 and 12 ka cal BP for Ireland and Newfoundland, respectively (McCabe and Dunlop 2006; Shaw *et al.* 2006). This created complex patterns of glacio-isostatic rebound and post-glacial sea-level history that vary across both islands as a result of local and regional fluctuations in ice loading and retreat. Newfoundland is characterized by three patterns: in the extreme northwest, rebound dominates such that relative sea level (RSL) fell throughout the post-glacial; in contrast RSL in the southeast rose continuously; and for the remainder of the island post-glacial RSL initially fell to a lowstand and rose to present sea level (J-shaped curve; Shaw and Forbes 1995). Ireland, on the other hand, is dominated by continuous sea-level rise until the present, with J-shaped curves restricted to the northeast of the island (Brooks *et al.* 2008).

The known archaeological records of both islands are restricted to the Holocene and, in their earliest phases, document the arrival of hunter-gatherers from an adjacent landmass (Labrador for Newfoundland, Britain for Ireland) followed by island-wide colonization. The earliest known occupation of Ireland by Mesolithic hunter-gatherers is currently dated to *c.* 9.7 ka cal BP (Woodman 1978; Bayliss and Woodman 2009) whereas Newfoundland's earliest dated occupation, by Maritime Archaic Indian (MAI)

hunter-gatherers, is currently placed at 6.3 ka cal BP (Bell and Renouf 2003). However, in both cases, the initial post-glacial occupation of the adjacent land occurred earlier – 9 ka cal BP for Labrador (Bell and Renouf 2003), up to 14–14.7 ka cal BP for Britain (Jacobi and Higham 2009; Ballin *et al.* 2010) – and coincided with periods of RSL below present levels. Despite lowered sea levels, terrestrial connections between Newfoundland/Ireland and the adjacent land did not exist at these times (e.g. Edwards and Brooks 2008), implying that watercraft were necessary for colonization. Further, there is evidence of coastal adaptation during the colonization period from adjacent regions such as shell middens on the west coast of Scotland, the earliest of which dates to *c.* 9.3 ka cal BP (Ashmore and Wickham-Jones 2009), and numerous coastal sites and marine hunting artefacts from southern Labrador dated to *c.* 9–8 ka cal BP (Renouf and Bell 2006) and also on Newfoundland and Ireland themselves from later post-lowstand MAI and Mesolithic sites (Woodman 1978; Bell and Renouf 2003). Taken together, this implies that the earliest colonists were a maritime-adapted society and suggests that evidence of this earliest occupation is now submerged. Having arrived, the mechanisms by which the earliest inhabitants dispersed across each island are poorly understood. For instance, did they expand using the coastline, or immediately move inland via river valleys? Again, submergence of the earliest record means that the answers must be sought underwater.

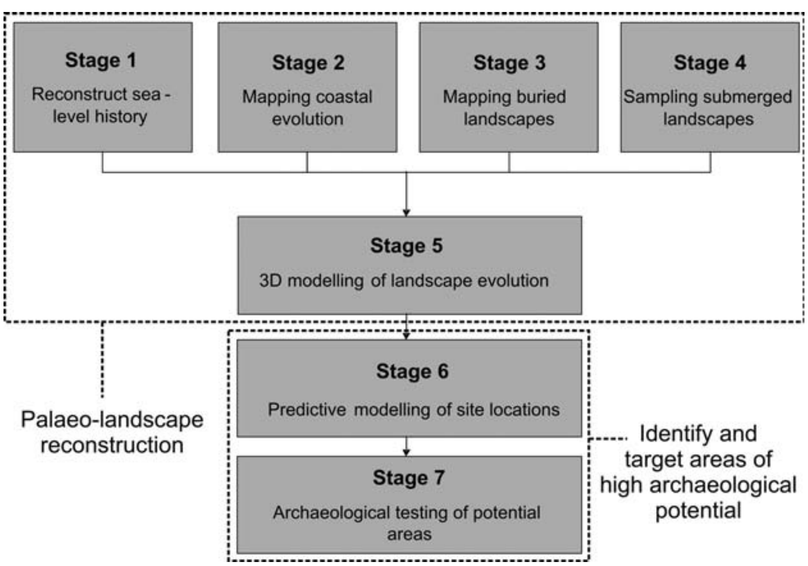
Our research currently focuses on two study areas: the north coast of Ireland and the northeast coast of Newfoundland (Fig. 11.1). Both experience relatively high-energy wave-

Figure 11.1: Location maps for the study areas in a) northeast Newfoundland, and b) the north of Ireland. Generalized patterns of post-glacial RSL change are also depicted



dominated conditions, which, at face value, imply erosion and loss of transgressed archaeological material. However, both also exhibit a diverse array of shoreline types with sheltered or more depositional locales interspersed with exposed high-energy zones. Moreover, previous studies have recovered prehistoric material from high-energy contexts (e.g. California [Masters 1983]), while burial under marine sand can also preserve evidence in such conditions (Flemming 1983). The north of Ireland has a relatively open linear coastline dominated by chalk, basalt or schist cliffs and headlands, rocky platforms, and extensive dune-backed sandy beaches. To the west, this linear shore becomes more irregular and is cut by three major sea loughs: Foyle, Trawbreaga, and Swilly (Fig. 11.1b). Within these, sheltered conditions allow the formation of beaches, dunes, intertidal flats, and salt marshes (Shaw and Carter 1994; Knight 2002). By contrast, northeast Newfoundland consists of an archipelago (Fig. 11.1a) with extensive (volcanic) bedrock shorelines interspersed with sheltered straits and bays bordered by rocky platforms and small sand, gravel, and boulder beaches. Additional environmental controls here are annual winter sea-ice formation, and common iceberg incursions following the spring ice melt (Williams and Currie 1995; Shaw *et al.* 1999).

Figure 11.2: Generalized diagram showing the progression of the SLAN research strategy. Stages 1–5 aim to acquire data and reconstruct the palaeolandscape, while Stages 6–7 use the reconstruction to identify and target areas of high archaeological potential for sampling and testing



Research strategy

The SLAN research plan is composed of seven stages, each of which requires interdisciplinary collaboration and the integration of computer modelling, geophysical survey, palaeolandscape interpretation, palaeoenvironmental analysis, and archaeological prospection (Fig. 11.2).

Stage 1: Reconstructing sea-level history

Reconstructions of sea-level history are based on a computer-modelled simulation of RSL changes that predicts the depth of submerged shorelines at specified time intervals. This simulation, commonly referred to as a glacio-isostatic adjustment (GIA) model, consists of a numerical analysis of the Earth's response to ice loading during the last glacial cycle. The model is constrained by ice volume change and observed indicators of past sea level (see Shennan *et al.* [2006] for an overview of the modelling process).

The use of GIA models is conditioned by the fact that geological, biological, or stratigraphic indicators of past sealevel position are typically discontinuous, commonly provide only constraints on past sea level rather than absolute index points and, in areas undergoing differential isostatic rebound such as Newfoundland and Ireland, only apply on a local scale (i.e. <10s of kilometres). Moreover, the majority of evidence best constrains periods when sea levels were higher than present due to the relative ease of obtaining datable material from terrestrial contexts. Therefore, both study areas are characterized by large gaps in the sea-level record and a dominance of constraining rather than absolute palaeo sea-level positions (Fig. 11.3).

Nevertheless, we recognize that the models are still limited by uncertainties in ice sheet growth/decay history, the Earth's rheological response, and the lack of observed sea-level data for calibration (particularly for lowstand periods). These limitations can result in discrepancies between the observed and modelled pattern of RSL (see for example the debate between Edwards *et al.* [2008] and McCabe [2008]). Where there are discrepancies we use both modelled and observed data to consider wider envelopes of RSL change.

Stage 2: Bathymetric analysis – mapping coastal evolution and landscape features

Stage 1 RSL simulations can be used to digitally shade or contour a bathymetric surface of the seabed and produce palaeogeographic maps charting the evolution of the coast. The main purpose of these reconstructions is to refine

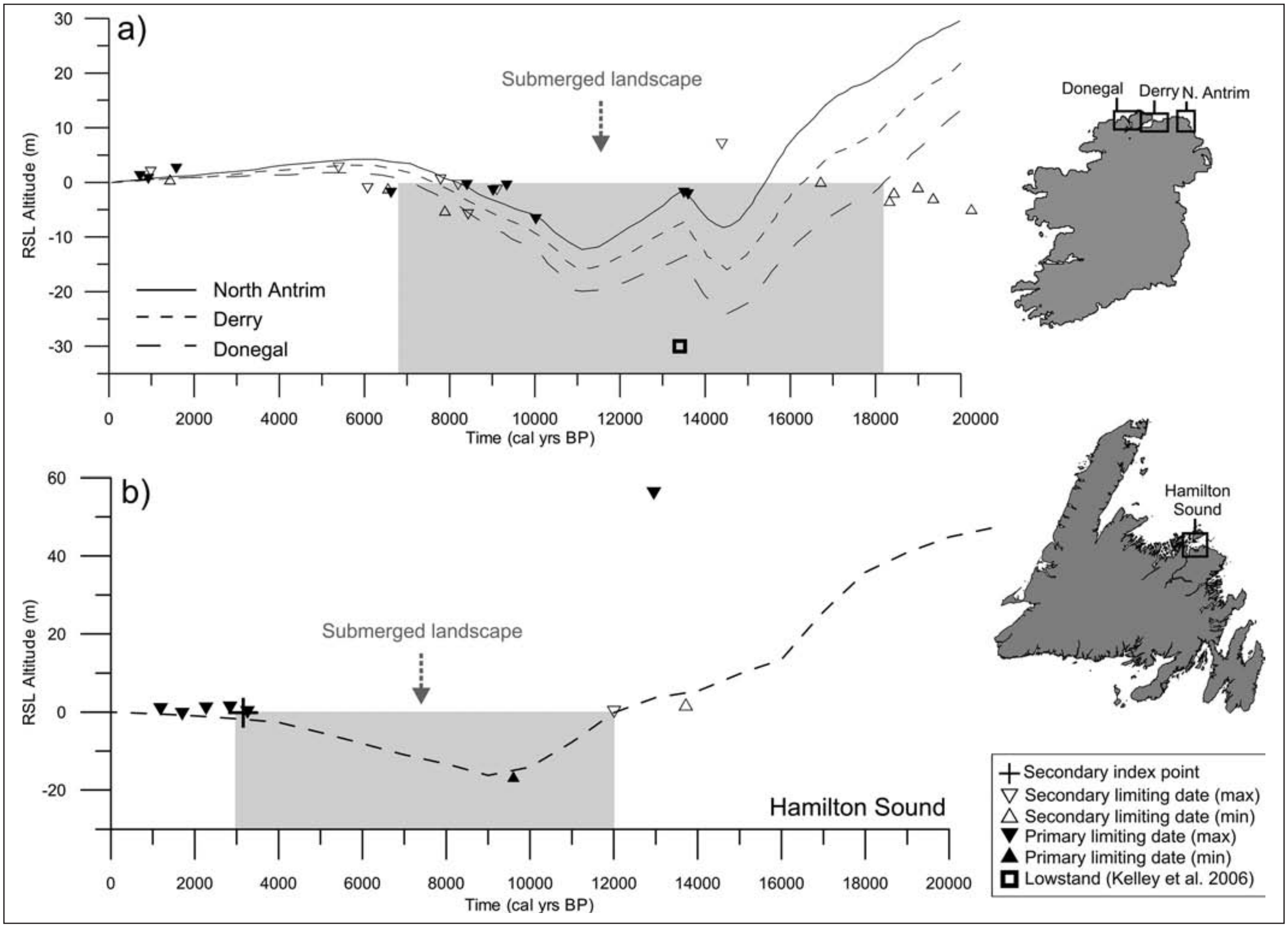


Figure 11.3: a) RSL data from the north coast of Ireland. Curves show estimates from a GIA model (Brooks et al. *2008), datapoints show dated geological evidence (Brooks and Edwards 2006). Note the discrepancy between the lowstand age and depth predicted by the models and that described by Kelley* et al. *(2006). b) RSL reconstruction for northeast Newfoundland (Hamilton Sound). Dashed line is the GIA-modelled reconstruction (Tarasov and Peltier 2005). Datapoints show dated RSL index points and limits (Shaw and Edwardson 1994). For both Irish and Newfoundland reconstructions note the large gaps and dominance of limits rather than absolute index points in the geological dataset*

areas of study and delimit zones to be targeted for detailed examination. At its simplest, this prioritizes analysis along, and inland of, predicted former shorelines while excluding areas that were underwater even during lowstands. Prioritized areas can then be scrutinized for geomorphic features relating to the past landscape that, in favourable circumstances, has survived transgression and is preserved on the seabed. Examples of such features imaged on the seabed include fluvial palaeochannels, shore platforms, spits, and barriers (Shaw *et al.* 2008). The importance of these features lies in the fact that they may indicate landscape preservation rather than erosion, may have formed environments favoured by past humans (e.g. river valleys) and may provide additional constraints on palaeo sea level (e.g. palaeoshoreline features), which can feed back into the RSL reconstruction. Distinguishing such features is greatly aided by use of digital bathymetric data rather than conventional paper charts, and 3D visualization software which employs various illumination angles, shaded relief effects, slope mapping, and vertical stretching to analyze the seabed surface image.

Ideally, this stage makes use of high-resolution (dm to m) bathymetry data collected by multi-beam echo sounder or LiDAR surveys. Lower-resolution datasets from hydrographic charts or single-beam echo sounder surveys can, and have been, successfully used in a similar manner. For instance, the Danish predictive model, which successfully located numerous submerged

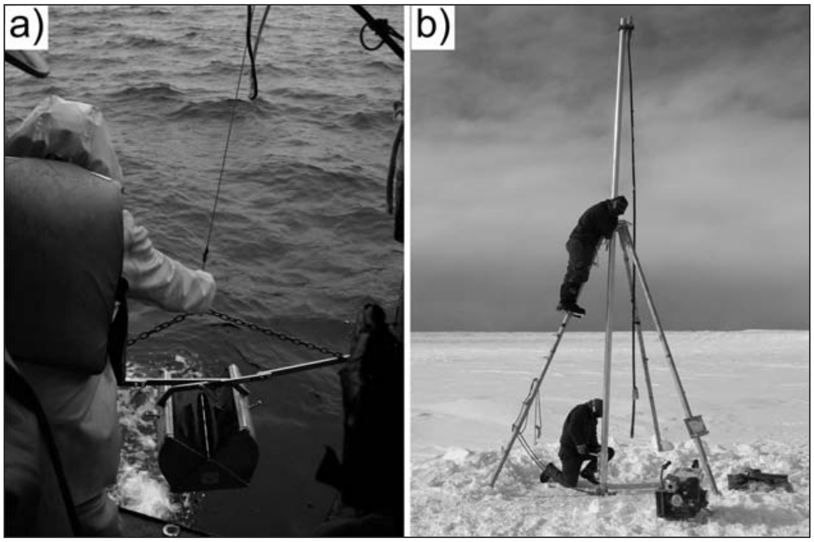
Mesolithic sites in the Baltic, was based on the identification of palaeotopographic features suitable for fishing with standing gear (e.g. straits and river mouths) from commercial hydrographic charts (Fischer 2004). However, their lower spatial resolution (i.e. 10s to 100s of metres between data points) can reduce the precision of palaeogeographic reconstructions and makes it difficult to detect smaller geomorphic features such as narrow spits, stream channels, inlets, and shore platforms.

Nonetheless, for both high- and low-resolution sources, it must be recognized that modern seabed bathymetry does not equate precisely to the pre-submergence landsurface due to post-transgression processes of sedimentation and erosion. Together with uncertainties in the RSL predictions, this means that bathymetry-based palaeogeographic reconstructions are first-order approximations and associated error margins should be stated when known.

Stage 3: Sub-seabed analysis – mapping buried features

Eroded landscapes (due to wave action, sea-ice scour, or currents) cannot be recovered, though there may be clues to eroded surfaces in the form of lag deposits on the seabed. However, buried and preserved surfaces can be traced by sub-bottom profilers (e.g. pinger, chirp and boomer systems), which acoustically penetrate the seabed to generate a vertical pseudo-cross-section of sub-seabed sediments. Stage 3 therefore involves the collection and analysis of such profiles to determine if elements of the past landscape are buried beneath modern seabed sediments. In a best-case scenario, the acoustic character and structure of these sediments permit the identification of buried geomorphic features, for example: freshwater lake basins, lagoons, shoreline terraces, infilled palaeochannels, and peat layers (Velegrakis *et al.* 1999; Plets *et al.* 2007). In other cases, it may only be possible to detect the presence of buried layers but not conclusively determine their nature without additional sampling.

Figure 11.4:
a) Deployment of Van Veen grab for seabed sampling off the northeast Newfoundland coast.
b) Deployment of sea-ice based percussion coring rig



Stage 4: Sampling submerged landscapes

Direct sampling programmes are designed to collect sediment that will ground-truth the acoustic interpretations from Stages 2 and 3 and also recover datable material for building transgression chronologies, and organic samples for palaeoenvironmental analysis. A variety of well-established techniques can be used depending on the equipment available, the sediment to be sampled, and its intended purpose.

Ship-deployed grab samplers (e.g. Van Veen, Shipek, or Day grabs: Fig. 11.4a) can collect unstratified bulk samples of surface sediment, which are primarily used to ground-truth interpretations of acoustic data (McDowell *et al.* 2007). Although surface sediment frequently consists of deposits produced by modern or post-transgression processes, seabed exposures of largely buried sediments imaged by sub-bottom profiles can also be targeted with grabs. Non-intrusive surface sampling can also be undertaken using observations from drop cameras, remotely operated vehicles (ROVs), or divers.

To access buried sediments, coring equipment – ranging from small diver-operated hand cores to larger ship-deployed gravity, percussion, or vibrocores – can be used to take long (up to several metres) samples of undisturbed and stratified sediment. In areas with significant sea-ice cover, coring rigs can also be deployed directly on the ice surface (Fig. 11.4b). Core samples are crucial in determining if buried layers imaged on acoustic profiles are remnants of the former terrestrial landscape, and for obtaining organic material to date transitions between terrestrial and marine sediments and thus build transgression chronologies (Edwards 2007).

Stage 5: 3D evolutionary models of the submerged landscape

Integration of data generated from the preceding stages can be used to portray accurate, fully three-

dimensional landscape evolution models. In this step, buried layers identified on 2D sub-bottom profiles on the basis of their acoustic character or sampling are digitally traced and linked to produce a continuous landsurface. The overlying post-submergence layers can then be digitally removed, effectively creating a reconstruction that is a better analogue of the former landscape than one created solely from bathymetric data. Similar work has been undertaken in the North Sea utilizing sub-bottom datasets from the petroleum industry (Fitch *et al.* 2005).

Stage 6: Mapping archaeological potential

Mapping archaeological potential is based on two characteristics of the reconstructed landscape: (i) landscape attributes that were favoured by past humans, and (ii) landscape settings that have the greatest potential for preservation of archaeological deposits.

Landscape attributes for consideration include general features such as proximity to freshwater, subsistence resources, shelter, lookout points, sources of raw material, and more specific features that vary depending on the particular strategies or preferences of a given society; for instance, the tendency for Danish coastal Mesolithic sites to be situated on topography suitable for fishing with standing gear (Fischer 2004).

Predictions of archaeological preservation are based on the identification of palaeolandscape deposits on or within the seabed from Stages 2–5. The accuracy of the predictions depends heavily on data availability. Ideally, ground-truthed acoustic data (see Stage 4) should provide definitive evidence of terrestrial sediments, for example peat layers imaged on sub-bottom profiles and sampled by corers. Less accurate predictions can be made from sub-bottom profiles alone, where the presence of sediment cover is suggestive of preservation even if it cannot be confirmed that the underlying buried layers are actually *in situ* terrestrial sediments. Finally, the least accurate inferences can be drawn from multibeam bathymetry and backscatter data alone where the simple presence of sediment may indicate a greater chance of burial and *in situ* preservation compared to areas of exposed bedrock. These site preference and preservation patterns are then applied to the palaeolandscape reconstructions of Stage 5, or, if not available, the coarser approximations developed in Stages 2 and 3.

Stage 7: Archaeological testing

Once identified, zones or sites of high archaeological potential can be subject to prospection and sampling to verify archaeological context, and to identify and recover archaeological material. Within the overall strategy, this is the culmination of the previous six stages. However, testing can also take place at an earlier stage, for example if guided by chance finds. This then can provide additional data that feeds back into earlier stages.

A variety of techniques can be employed for archaeological testing, depending on the water depth and environmental conditions of each targeted site. Scuba survey is most effective in calm, shallow waters with good visibility, where the archaeology lies on, or just beneath, the seabed surface and can be detected visually or by hand fanning. However, more deeply buried sites require intrusive techniques such as sampling by induction dredges (Faught 2004). In conditions less amenable to diving, remote techniques such as sub-bottom profiling ROVs or grabs can be employed (Wessex Archaeology 2008). Finally, in very shallow or intertidal areas, scuba or snorkel surveys can be supplemented by on-foot surveys at low tide (McErlean *et al.* 2002).

Case studies

The majority of the work completed from both study areas has focused on analysis of sea-level reconstructions, bathymetric data, and site prediction modelling (Stages 1, 2 and 6). Limited intertidal archaeological survey (Stage 7) has also been undertaken for northeast Newfoundland. Thus far, the work undertaken has constrained first-order palaeogeographic reconstructions that will be used to inform more extensive palaeoenvironmental sampling programmes, form the basis for a more comprehensive reconstruction, and ultimately guide extensive archaeological testing surveys (Stages 4, 5 and 7). The flexibility of the strategy is illustrated by the fact that, in Ireland, stage progression is largely in order and made possible by the provision of extant bathymetric and sub-bottom datasets covering much of the study area. Conversely, in Newfoundland, research has proceeded in a more opportunistic manner, focusing on smaller areas and with stages run out of sequence as and when different datasets become available.

North coast of Ireland

Sea-level change and palaeogeographic reconstruction

According to the GIA model of Brooks *et al.* (2008) early post-glacial RSL on the north coast of Ireland was high (*c*. 20 m above present at 20 ka cal BP) as a result of glacio-isostatic depression, and subsequently fell to a lowstand depth sloping westward from -12 to -25 m between *c*. 13–11 ka cal BP (Fig. 11.3a). After the lowstand, RSL rose to present levels or a minor highstand (up to *c*. 3 m above present) by 7.5–8.0 ka cal BP. By contrast, possible wave-truncated features have been interpreted to show a lowstand depth of -32 m at 13.4 ka cal BP before RSL rose to the Middle Holocene highstand (Kelley *et al.* 2006). However, this lowstand is not dated directly, and may not be valid across the study area since differential isostatic rebound is likely to have created a spatially variable pattern of RSL change (Brooks *et al.* 2008). Given these discrepancies, we consider both estimates and use them to define an envelope of possible sea levels for the study area. These factors also indicate that part of future acoustic and sampling programmes should be directed to finding additional constraints on lowstand sea-level depth and age that can feed back into the GIA model.

These initial RSL estimates were applied to high-resolution multibeam bathymetry to produce first-order palaeogeographic reconstructions, identify submerged landforms, and delimit areas of study. This was aided by provision of the Joint Irish Bathymetric Survey (JIBS) dataset, a collaborative project between Northern Ireland and the Republic of Ireland, which has provided full-coverage multibeam bathymetry along the coastal strip from Fanad Head to Torr Head. Though these data were collected for navigational purposes, they were made available for all types of scientific research (Westley *et al.*, in press).

The reconstructions show that the palaeo-coastal strip along the north coast was relatively narrow during the earliest known Mesolithic occupation, extending out from the modern shoreline by several hundred metres to several kilometres. The largest extensions are found in modern bays and the modern sea loughs of Lough Swilly, Trawbreaga, and Foyle (Fig. 11.5). During the lowstand these loughs likely contained river systems that drained across the exposed shelf. Palaeochannels however, are not visible on the bathymetric data, probably because they were infilled and buried by marine sediment as they were transgressed. This is supported by

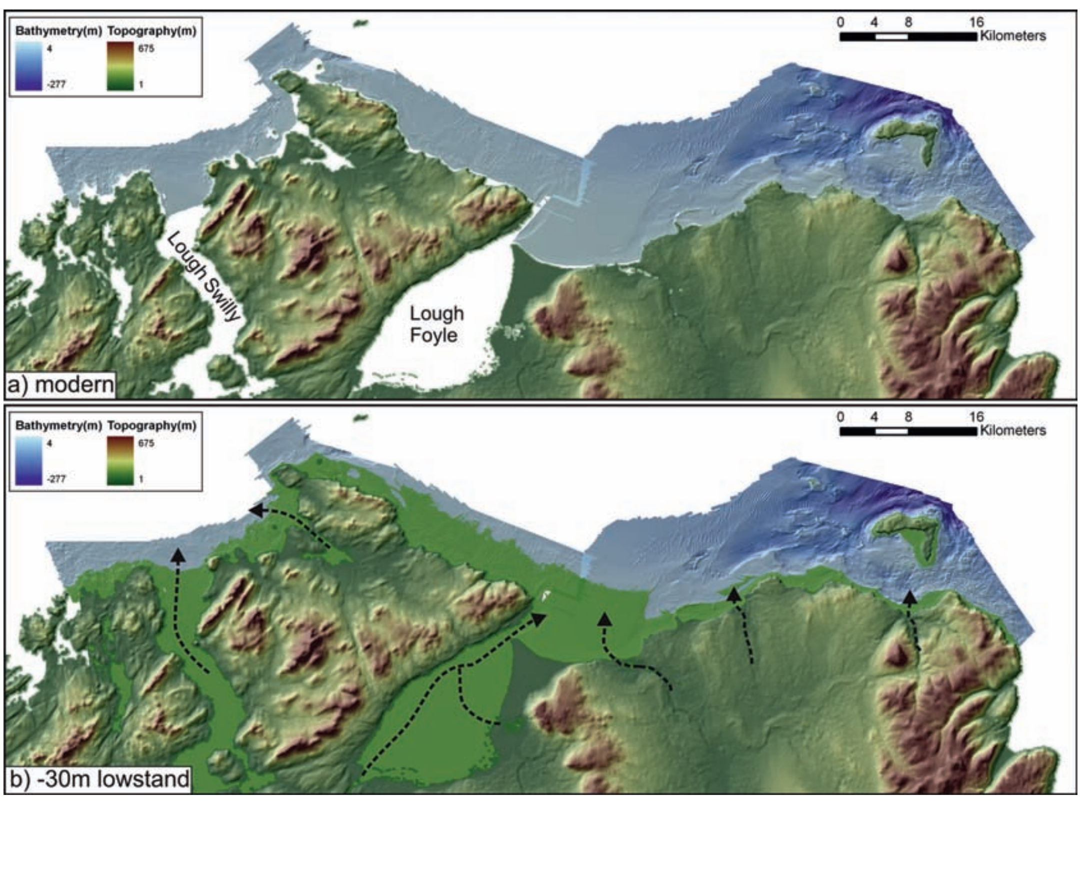


Figure 11.5: a) Modern coastal configuration for the north of Ireland. The seabed north of the modern shoreline has been mapped by the JIBS survey. Blank areas show where there is no multibeam coverage. b) Approximation of the lowstand coastal configuration assuming a sea-level fall of 30 m (Kelley et al. *2006). Areas shaded light green show the extent of the exposed shelf. Note the narrow shelf extension in the west and the closure of the modern sea loughs to form fluvial valleys. Black dashed arrows indicate the likely paths of rivers. Given the discrepancies between the geological interpretation and the GIA model (see Figure 11.3a), this should be regarded as the maximum extent for the submerged landscape*

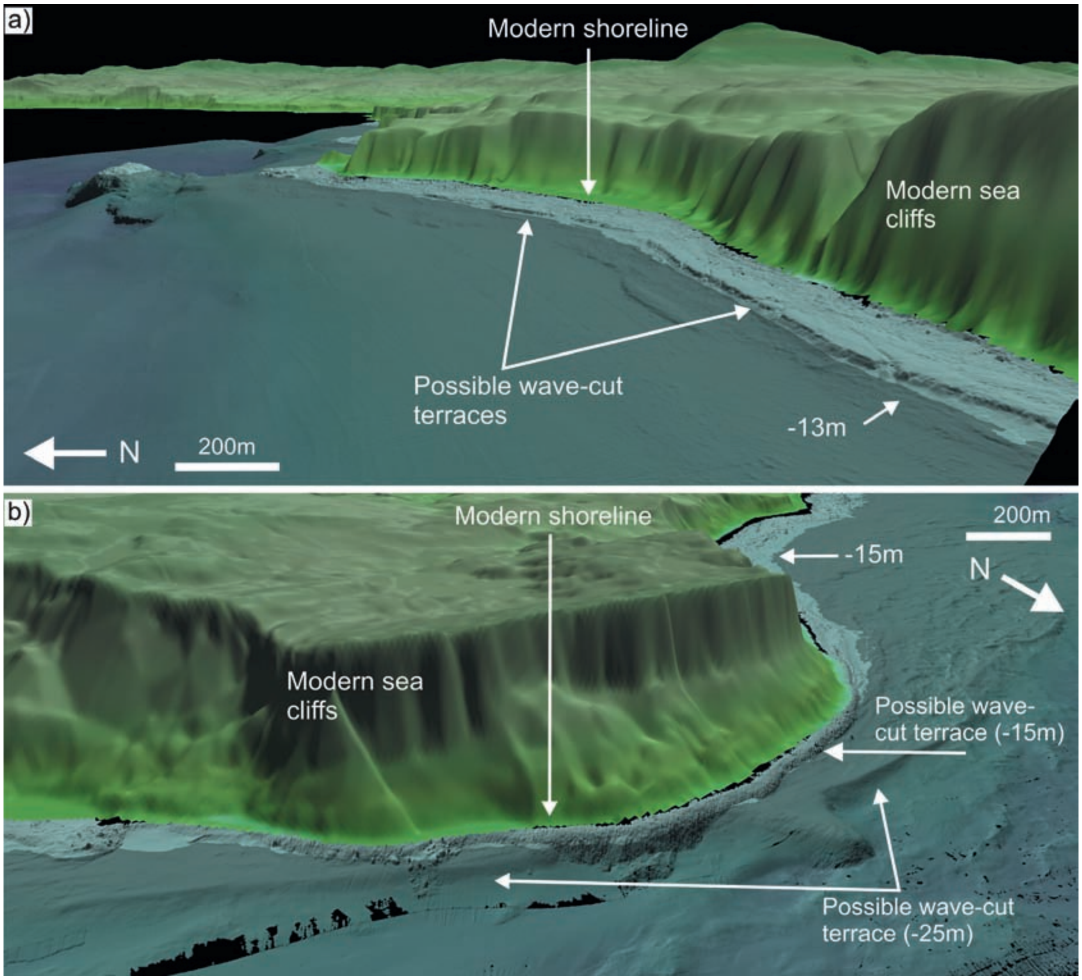


Figure 11.6: Possible shore platforms/wave-cut terraces imaged off County Antrim by the JIBS dataset and combined with a terrestrial digital elevation model (from the Ordnance Survey of Northern Ireland). Images have 2x vertical exaggeration. a) Platforms situated to the west of Ballycastle Bay. Modern cliffs are c. *100 m high. b) Terraces situated off Fair Head. Modern cliffs here are* c. *200 m high*

the presence of possible buried palaeochannel features interpreted from sub-bottom profiles (Cooper *et al.* 2002; McDowell *et al.* 2005).

Visual analysis and slope mapping of the reconstructions also identifies a series of potential shoreline features that are particularly well developed off Co. Antrim (Fig. 11.6). The most consistent slope break lies at *c*. -15 to -13 m, with the possibility of a deeper cliffline, the top of which is at -20 m and its base at -35 to -40 m. The extent and precise depth of this latter feature is uncertain as it is partly buried by slump deposits. The shallower platform fits well with the GIA model, which predicts a lowstand of *c*. -12 m at 11 ka cal BP (Brooks *et al.* 2008), whereas the lower feature fits better with the interpreted lowstand of -32 m (Kelley *et al.* 2006). Interpretation of these features as wave-cut shorelines is supported by the fact that both the modern and Middle Holocene highstand shorelines in this area consist of cliff-backed rocky platforms or terraces. If dated, they would provide additional constraints on the RSL reconstruction. Nonetheless, further research is needed to confirm this preliminary interpretation, particularly in light of the fact that local geomorphology is strongly controlled by structural weaknesses in the bedrock and local variations in wave strengths as well as the height of contemporary sea level (McKenna *et al.* 1992).

Site location modelling and archaeological potential

Previous research has provided qualitative insights into spatial patterns and landscape settings of the Irish Mesolithic. The distribution of known sites is heavily influenced by the history of archaeological research and taphonomic factors affecting artefact preservation and exposure. For instance, the largest concentration of Mesolithic sites occurs in northeast Ireland where there has been a tradition of artefact collection since the 19th century AD and where the Middle

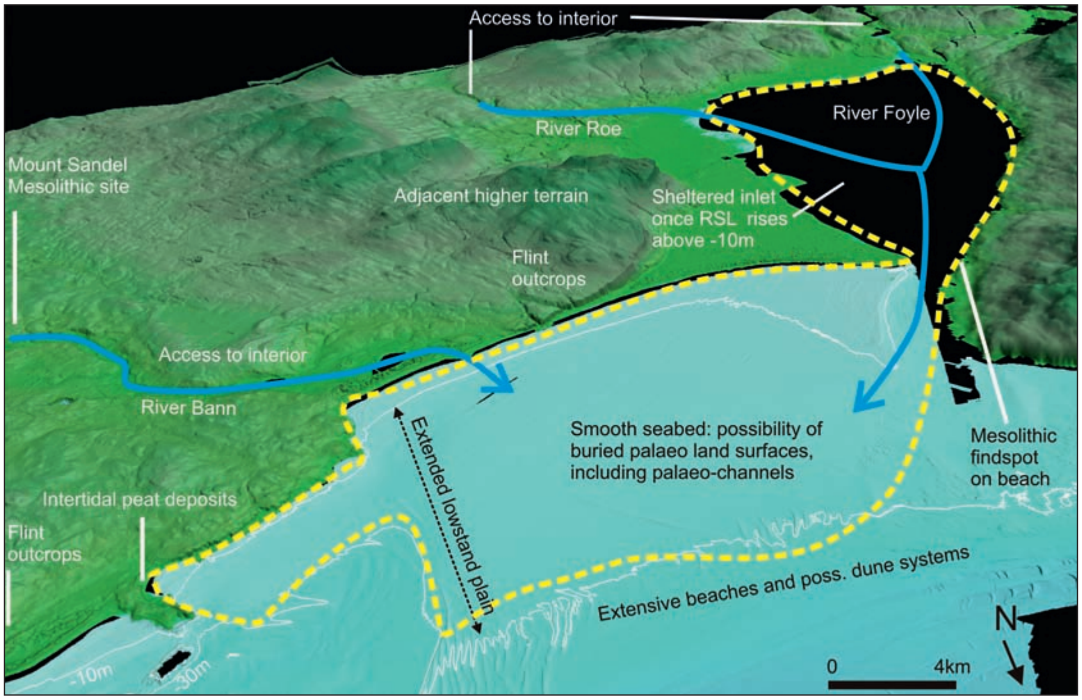


Figure 11.7: Combined terrestrial and seabed digital elevation model off the Bann and Foyle estuaries, annotated to show area of high archaeological potential and the reasons for its classification. Image has 2x vertical exaggeration

Holocene highstand created raised beaches on which numerous Late Mesolithic sites have been found (Woodman *et al.* 2006). Within this regional distribution, site concentrations indicate that Mesolithic hunter-gatherers preferred to locate themselves along river valleys, lakeshores, and marine coastlines. This, along with faunal evidence such as shell middens and fish remains attests to the importance of coastal and freshwater resources in their subsistence strategies (Woodman 1978).

In an initial phase of analysis based on the first-order palaeogeographic reconstructions, ten high-potential areas were defined on the basis of the site location preferences and preservation potential (Westley *et al.*, in press). One of these, the seabed offshore from the Bann and Foyle estuaries, is presented here as an example (Fig. 11.7). First, it is classified as an area of high archaeological potential because the environments preferred by Mesolithic hunter-gatherers occurred within it during the RSL lowstand. Freshwater environments were provided by the Bann, Roe and Foyle rivers, which crossed the exposed coastal lowlands fronting the modern shore. In addition to freshwater resources, these rivers provided easy access through the former heavily forested interior. Access to marine resources was provided by the extensive beaches that fronted the coastal lowland, facilitating the landing of boats and watercraft. Although this landscape may initially appear quite exposed, the existence of offshore sand deposits raises the possibility that these beaches were backed by proto-dune systems that could have provided shelter (Wilson and McKenna 1996). Lithic raw material is also present within this area in the form of exposed flint-bearing chalk cliffs.

Second, higher preservation potential is suggested by extensive offshore sand deposits, which could have buried and preserved palaeo-landsurfaces and associated archaeological material, a hypothesis supported by the imaging of buried channel fills off the Bann Estuary (McDowell *et al.*, 2005). Further indications of preservation come in the form of Early Mesolithic material possibly eroded from a submerged deposit and washed onto a beach at Greencastle, eastern Lough Foyle (McNaught 1998), and intertidal peats preserved on Portrush West Strand (Carter and Wilson 1990), from which Mesolithic material has been collected (Patterson 1896).

Northeast Newfoundland

Sea-level change and palaeogeographic reconstruction

RSL change on the northeast Newfoundland coast followed the 'J-shaped' curve characteristic of much of the island (Shaw and Forbes 1995). As ice retreated, the isostatically depressed land was flooded creating a highstand of *c.* 40–50 m above

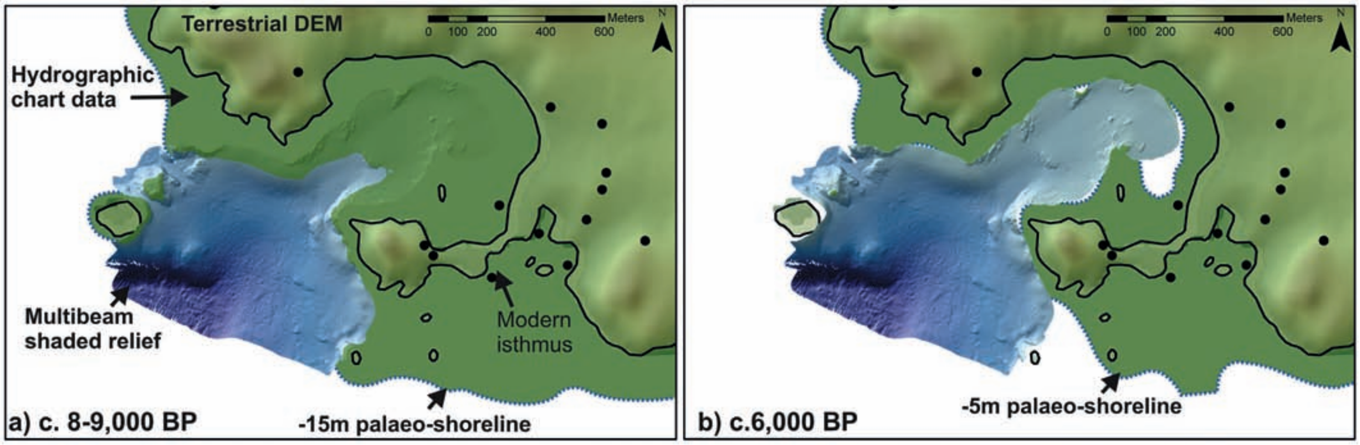


Figure 11.8: Merged terrestrial (from Geobase.ca) and marine shaded relief models for Back Harbour showing coastal configuration at a) the 8–9 ka cal BP lowstand, and b) c. *6 ka cal BP when there was a confirmed MAI occupation (sites represented by black dots) of terrestrial areas. Black line delineates the modern coastline. Note that multibeam coverage is limited to the modern harbour and immediately adjacent waters. Depth estimates from the surrounding area are from a hydrographic chart*

present at *c*. 13–14 ka cal BP. RSL subsequently fell below present by 12 ka cal BP to a lowstand of -18 m at 9.6–10 ka cal BP. It then rose again reaching modern levels by 3.15 ka cal BP. This pattern is based on geological evidence (Shaw and Edwardson 1994) and reasonably well replicated by the GIA model of Tarasov and Peltier (2005), which also shows the depth of the lowstand decreasing west across the study area (Fig. 11.3b). Nonetheless, we recognize the need for additional lowstand constraints, particularly in light of misfits between the GIA model and RSL evidence from elsewhere on Newfoundland and the likelihood of spatially variable isostatic rebound and sea-level change within the study area.

These RSL data have been applied to multibeam bathymetry to create first-order palaeogeographic reconstructions and identify lowstand landforms. The acquisition of multibeam sonar data for our analysis illustrates an ideal scientific collaboration and partnership with marine mapping agencies. The multibeam data were acquired by the Canadian Hydrographic Service (CHS) for navigational purposes, while the survey area was chosen by Fisheries and Oceans Canada (DFO) to characterize and delineate demersal capelin spawning habitat. According to seabed sampling, this habitat roughly coincided with the RSL lowstand depth and was dominated by well-sorted medium sand to pebble gravel (Davoren *et al*. 2008). Therefore it was initially hypothesized to comprise submerged lowstand beaches because capelin normally spawn on modern beaches with similar textural characteristics. SLAN established a formal joint agreement with CHS to use the multibeam data and worked with DFO scientists to collect seabed samples and sub-bottom profiles to ground-truth the multibeam data and, at the same time, target potential submerged archaeological landscapes.

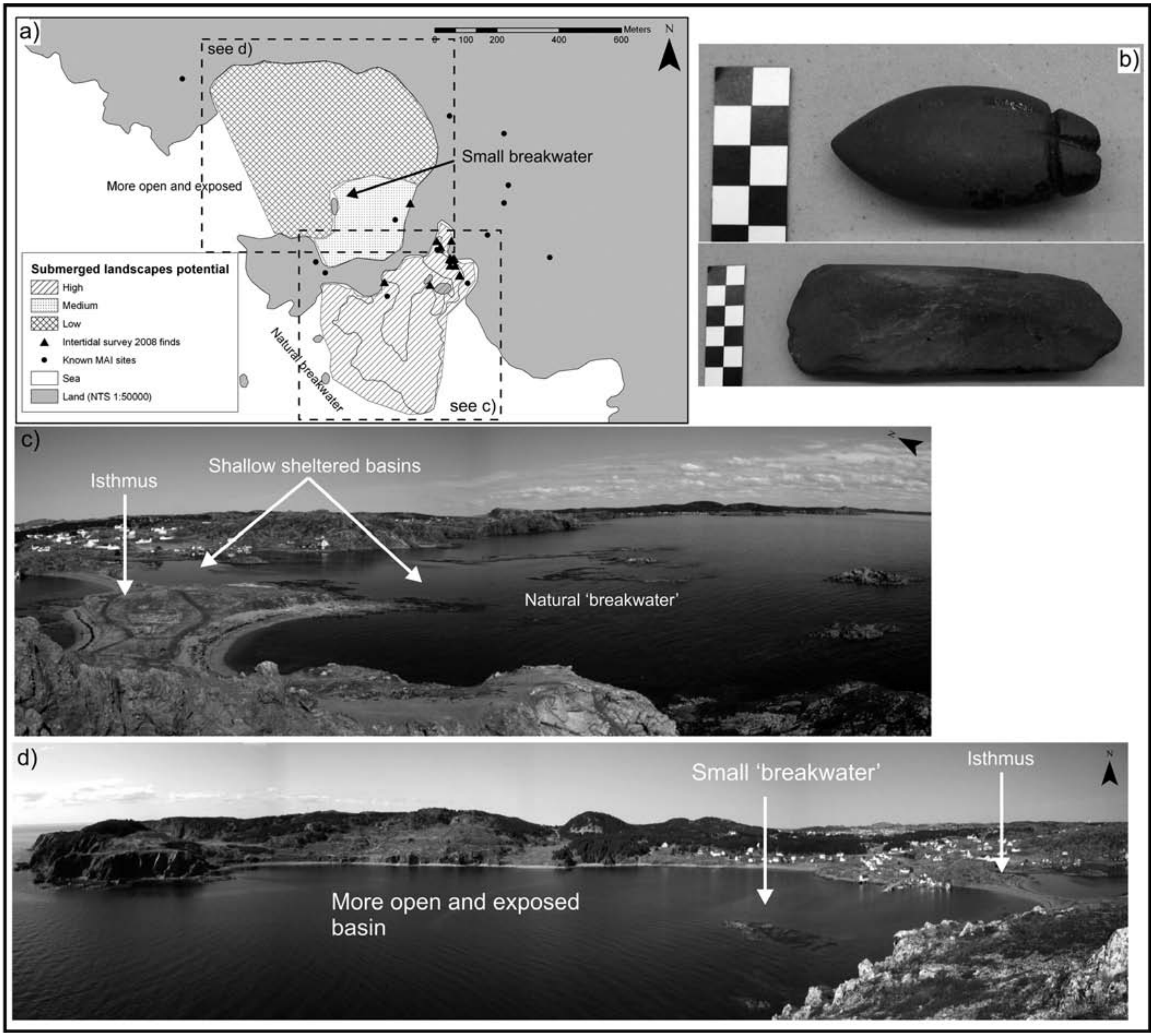
The palaeogeographic reconstructions presented here show the evolution of a small bay, Back Harbour, over the Holocene marine transgression. Back Harbour is a shallow semicircular cove bounded by low hills and, on its southern side, a small island linked to the mainland by a narrow isthmus. South of the isthmus is an extended area of intertidal shallows and rocky reefs. Multibeam coverage is limited to the main body of the harbour and adjacent deeper water, as survey was not possible within the shallows. During the lowstand, the harbour was reduced to a small inlet at the mouth of the modern cove (Fig. 11.8a). Since the bathymetry shows a continuous slope from the modern coast to the palaeoshoreline it is likely that the small streams draining the adjacent higher ground flowed directly across the exposed land. As sea level rose during the early MAI period, the harbour was flooded and enlarged attaining a configuration similar to the present by 5–6 ka cal BP (Fig. 11.8b). To the south of the main harbour, the landscape was extended by the exposure of the intertidal shallows and reefs. Hydrographic chart data suggest that these formed a relatively consistent and extensive level surface that retreated in a linear manner with rising RSL. However, an archaeological survey (see below) confirmed that the topography of this area was more complex than indicated by the low-resolution data, with large rocky outcrops and small inlets fronting the area of shallows. The pattern of retreat here is therefore uncertain, but may have included the formation, or migration, of small channels, inlets, and reefs.

Figure 11.9: a) Location of intertidal survey finds and classification of submerged archaeological potential within Back Harbour. b) MAI plummet (top) and stone axe (bottom) collected from the intertidal zone at Back Harbour by a local resident. c) Overview of south portion of Back Harbour showing the natural breakwater and sheltered basins. d) Overview of north portion of Back Harbour showing the more open and exposed cove

Site location modelling and archaeological potential

Predictive modelling of Maritime Archaic site preferences on Newfoundland is well advanced (Renouf and Bell 2006). This model shows that regional site distributions were controlled primarily by resource abundance and that resource access influenced site position within the local landscape setting. Thus, 84% of all sites are found by the coast, a reflection of the importance of marine resources, with concentrations of sites where a variety of resources (e.g. harp and harbour seals, and seabirds) are abundant. Coastal sites are particularly concentrated in coves (63% of all coastal sites) and situated within 500 m of easily accessible higher ground, up to 65 m above sea level (70% of all sites), and fresh water (89% of all sites) (Renouf and Bell 2006). This highlights the MAI preference for sites to be positioned in sheltered areas with access to coastal resources, fresh water, and elevated resource monitoring stations.

Application of the model to the Back Harbour reconstructions, and consideration of preservation issues, suggests it has high submerged archaeological potential. Back Harbour at the RSL lowstand consisted of a small exposed cove along a relatively straight section of coast. Although the extent of sheltered water and access to the sea was relatively limited during this initial



period, it increased as the harbour was flooded and enlarged. The site location model indicates that relatively few exposed sites are found on Newfoundland compared to sheltered locales. However, known exposed sites are found mainly in Notre Dame Bay, the water body bounding Back Harbour. The likely reason is that this was a prime area to hunt harp seal on their southward winter migration, a fact reflected by the high density of 19th century seal-hunting locations in similar positions to the known MAI sites (Renouf and Bell 2006). Further advantages include the presence of fresh water in the form of streams and a now-dry pond, monitoring stations in the form of headlands overlooking the sea, and relatively level ground around and within the harbour. Finally, Back Harbour was densely occupied during the late MAI (Wells and Renouf 2008) and given the advantages described above there seems little reason to suggest that the same was not true of the early MAI.

In terms of preservation potential, multibeam data show a smooth seabed with protruding rock outcrops, implying sediment deposition and, therefore, a higher likelihood of burial rather than erosion of palaeolandsurfaces. This is supported by sub-bottom profiles, which indicate sediment layered on top of the bedrock, though the origin of the layers cannot be presently confirmed without further sampling.

Archaeological testing

Archaeological testing consisted of an intertidal survey of Back Harbour. This aimed to locate artefact concentrations within the intertidal zone and refine understanding of the potential location of submerged archaeological deposits. The choice of area was twofold, made on the basis of MAI material from the intertidal zone collected by a local resident (Fig. 11.9b) and its identification as an area of high archaeological potential (see above). The survey identified concentrations of non-diagnostic lithics, which in conjunction with previously collected MAI tools, indicated a higher potential for preserved material within the intertidal and subtidal sediments in the shallows south of the main harbour (Fig. 11.9a).

This enhanced preservation is created by a series of rocky outcrops fronting the shallows, which form a natural breakwater and reduce the impact of waves. This was not identified in the initial assessment (see above) because this area was not covered by the multibeam survey and the conventional hydrographic chart was of insufficient resolution to resolve these features. The lack of intertidal finds from the main harbour combined with greater wave exposure relative to the southern shallows resulted in it being reclassified as less archaeologically prospective (Figs 11.9c and 11.9d). This is not to say that no preservation here is possible, rather that it may take the form of localized pockets (such as behind the small breakwater within the main harbour) instead of extensive preserved landsurfaces.

Conclusion and future work

This paper has outlined a stepwise research strategy for the investigation of submerged archaeological landscapes, which has been applied in Newfoundland and Ireland. The work done thus far has constrained sea-level and palaeogeographic reconstructions which, when combined with archaeological site modelling, have allowed the identification of areas of archaeological potential. These results alone are not capable of addressing the SLAN goals of understanding past population expansion and response to environmental change. However, they provide a secure foundation on which future research can build. More specifically, identified areas of archaeological potential can be targeted for prospection and sampling. It is intended that this will ultimately recover datable archaeological material that can answer questions regarding the timing and pattern of Newfoundland and Ireland's initial colonization. For example, whether the 3000-year gap between the colonization of Labrador and Newfoundland is real or the product of submergence of the oldest Newfoundland sites. Importantly, even at this early stage, we also are identifying the essential palaeolandscape context needed to address questions on past human response to environmental change. For instance, if Mesolithic hunter-gatherers were occupying the Bann and Foyle estuaries during the lowstand, then what impact might rapid shoreline retreat or channel migration have had on their settlement or subsistence patterns? Could the retreating shores have promoted inland migration or stimulated further movement around the island's coasts?

Considerable future work is planned, which will focus on further palaeolandscape investigation to enhance the existing first-order

reconstructions and archaeological sampling of identified high-potential areas. For both study areas, palaeolandscape investigation will focus primarily around the interpretation of sub-bottom and ground-truth data (Stages 3 and 4) and its integration with the sea-level and multibeam analysis of Stages 1 and 2. An extensive dataset of sub-bottom profiles has been collected off much of the north coast of Ireland since 1998, sections of which have previously been analyzed from a geological perspective (Cooper *et al.* 2002; Kelley *et al.* 2006), and has been supplemented by newly acquired profiles and ground-truth data collected in December 2009. For northeast Newfoundland, existing data (Shaw *et al.* 1999) will be supplemented by data collected in August 2008. At the time of writing, full geoarchaeological analysis of these datasets had only just begun and a complete interpretation was not available. Nonetheless, initial examination showed that some areas (e.g. The Skerries, Ireland, and Moreton's Harbour, northeast Newfoundland) are characterized by a complex sub-seabed stratigraphy indicating that pre-transgression deposits have been buried and preserved. This highlights the potential of the data to enhance existing coarse palaeolandscape reconstructions and archaeological potential predictions.

Ultimately, it is intended that this work will result in accurate Stage 5 3D reconstructions for both northeast Newfoundland and the north of Ireland, which can then be classified in terms of archaeological potential and archaeologically tested (Stages 6 and 7). Extensive testing will not proceed until these refined models have been constructed. However, small-scale underwater surveys are planned for areas where coarse predictions of archaeological potential and known finds suggest the preservation of submerged landscapes. For example, at Back Harbour, coring (either by hand augers or sea-ice based core rigs) will be combined with snorkel and scuba surveys in the high-potential southern shallows, to test the hypothesis that buried landsurfaces are preserved in the intertidal and subtidal zone and locate the source of the intertidal MAI finds. For the north of Ireland, diver-operated hand cores will be deployed off Portrush West Strand to trace known intertidal peats into deeper water and recover material for dating. Dive surveys are also planned for Greencastle, where visual inspection and hand coring will attempt to identify the source of Early Mesolithic finds currently found washed onto the modern beach.

To conclude, the investigation of the submerged prehistory of Newfoundland and Ireland is still at a relatively early stage. However, we believe that the development and adoption of a flexible, interdisciplinary strategy, which makes use of data and techniques in common use by industry and the marine scientific community, and which aims to not only locate submerged archaeological material but also place it in a valid palaeolandscape context, gives us the best chance of success in these environments.

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12

Submerged Prehistory in the Americas

Michael K. Faught and Amy E. Gusick

In this chapter we outline what we know about submerged prehistory from the American perspective by revisiting places where researchers have actively searched for sites, places where sites underwater are known, and places that have great potentials for discovery. We describe our own works conducted on the East and West Coasts of North America: the eastern Gulf of Mexico, Apalachee Bay, Florida, and the western Gulf of California, Bahía Ballena, Baja California Sur. These two projects, located in different geological environments, with different culture-historical backgrounds, and situated in different marine settings, show some of the benefits of initiating research where submerged palaeolandscapes are easier to access because they are exposed or shallowly buried on the seabed.

Keywords: submerged prehistory, underwater archaeology, Americas

Introduction

If it can be said that scientific enquiries evolve as specific disciplines as their contributions grow, their theory, assumptions, and methods improve, and students seek out mentors to become proficient specialists, then this volume shows that submerged prehistoric site archaeology is becoming a discipline in its own right in Europe (Bailey and Flemming 2008). The same is not quite true in the Americas, but it is close. Of course anthropological questions about coastal adaptations and migration routes remain in America today, which can only be resolved with data from underwater settings on the continental shelf, as has become apparent to oceanographers and archaeologists alike since the 1960s (Emery and Edwards 1966; Kraft *et al.* 1983; Ruppe 1988; Stright 1990; Erlandson 2006; Ballard 2008).

Because it is expensive to go to sea, difficult to model what the seafloor looked like before submergence, and difficult to work under the sea, what drives this kind of research? There have to be motives for researchers to go to such lengths. Issues that motivate (or have funded) prehistoric underwater research in the Americas include fundamental questions about coastal adaptations; for example, when, why, and where did people begin to access coastal habitats (Erlandson and Fitzpatrick 2006)? Did people only go to the coast when other resources were stretched between 6000 and 5000 cal BC, at the same time as seas transgressed to near-modern levels, or did the majority of populations settle within a short distance of the coast, as is the case today, with evidence for them missing because sea-level rise covers those palaeocoastlines? Gusick's research described in brief below is motivated by this anthropological question, and evidence is accumulating that the latter is more likely.

Another motive for looking for submerged prehistoric sites is to identify migration pathways. While the Pacific Coast of North America is the logical place to look for migration routes into the Americas, alternative, data-based models are accumulating about different pathways of the initial peopling of the Americas that include East Coast pathways and ocean crossings (Dixon 2001; Bradley and Stanford 2004; Faught 2008). Recent projects in North America are focused on locating evidence to support a hypothesized Pleistocene coastal migration along the Pacific Coast of the Americas (Josenhans *et al.* 1997; Fedje and Josenhans 1999; Gusick and Davis 2007, 2009, 2010). Another project in the Gulf of Mexico is focused on finding 'pre-Clovis'

Figure 12.1: Locations of sites and areas discussed in the text, with generalized extent of the continental shelf and limits of Pleistocene glaciation at 18 ka BP (21.5 ka cal BP) and 10 ka BP (11.5 ka cal BP)

habitation sites in deep water settings that might be indicative of Iberian rather than Siberian origins for Clovis technology (Adovasio and Hemmings 2009, 2010).

Cultural resource management (CRM) projects offer other, not so theoretical, motives to conduct submerged prehistoric sites archaeology and, it will be shown, these kinds of projects have had important impacts on methodology and site discovery, and probably will continue to do so in the future. State and federal agencies have need for complete settlement pattern information, which logically includes bays, inlets, and continental shelf areas; projects often have funding levels of appropriate scale, and the archaeologist has the benefit of legislative compliance to compel attention to threatened resources.

Where are the sites and who's looking in the Americas?

The diversity of locations with potential for the preservation of submerged prehistoric sites in the Americas is as remarkable as is its areal extent. Human presence is confirmed as early as *c*. 12,000 cal BC when sea levels are in the first meltwater pulse (MWP-1a) of the Late Pleistocene. Fluted points, the previous suspect for first people, expand later at *c*. 11,000 cal BC, at the beginning of the Younger Dryas in both North and South America. Human occupation is confirmed everywhere in North, Central, and South America by *c*. 9500 cal BC, in the Early Holocene (Faught 2008). It is more than probable that any palaeolandscapes exposed during those times were known to, and exploited by, people.

In general, the eastern coasts of North, Central and South America exhibit large areas of low slope continental shelf, with many estuarine bays and inlets, while the western coasts exhibit narrower continental shelves, active volcanism and tectonism, and high-energy marine conditions, with fewer situations favourable to preservation, except in bays, inlets, and island clusters. Submerged prehistoric sites are known from both coasts.

Compilation of submerged prehistoric sites known in the Americas begins with Nic Flemming's (1983) chapter of where sites are being found around the world, and why they are preserved. He pointed out that British Columbia, Southern California, Yucatan, and Florida had produced the majority of known sites in the Americas, and this remains the case today (Fig. 12.1) (Faught 2004; Fedje and Mathewes 2005; McKillop 2005; Masters 2010). Other early volumes focused on submerged prehistoric sites in the Americas include Bailey and Parkington (1988) and Johnson and Stright (1992).

Montague Harbour, in British Columbia, is an excellent example of a large Middle Holocene shell midden with deep stratigraphic extent that continued from land into the water. This midden was remotely sensed with sub-bottom profiler, and then cored and excavated underwater. This is surely one of the earliest examples of such combined methodology (Easton and Moore 1991; Easton 1992). More recently, important, sustained research terrestrially and underwater has been conducted in Haida Gwaii, in and around Hecate Strait by Parks Canada archaeologists. Their underwater research employs swath bathymetry, seismic profiling, and clam-bucket sampling to understand relative sea-level rise and isostatic rates. This methodology allows the researchers to reconstruct palaeolandscapes of different time frames, find early sites, and test Pacific Coast migration models (Josenhans *et al.* 1997; Fedje and Christensen 1999; Fedje and Mathewes 2005).

Terrestrially-based research conducted on the Channel Islands and the mainland of California has confirmed early coastal adaptations and implies earliest Holocene use of boats (Erlandson 1997; Erlandson *et al.* 2008). Although no submerged prehistoric sites are known from the islands, they are highly likely to exist on the slopes and canyons that surround the islands

underwater. On the other hand, Southern California has produced thousands of mortars and other ground and chipped stone artefacts from offshore contexts since 1915 (Masters 1983, 1985, 1998). Of the theories proposed to account for how these artefacts came to be deposited underwater, ceremonial deposition from a boat (ethnographically attested in local proto-historic accounts) and/or rising sea level inundating once-terrestrial sites are likely explanations, and, depending on the particular site and its assemblage, both are true (Masters 2010). Sites are known between Point Conception, California, and the United States–Mexico border, along the San Diego County coastline, and in the Santa Barbara Channel (Masters 1985: 28).

In the Gulf of Mexico, some of the most important work in assessing the potential for submerged prehistoric sites and the development of principles and methodologies for finding them, began with a CRM report for the Minerals Management Service (MMS) by Coastal Environments, Inc. (CEI 1977), which mapped probability areas for submerged historic and prehistoric sites in need of protection from oil and gas explorations. With focus on the prehistoric record, this document identified the culture history, geology, and sea-level characteristics of the Gulf, and especially the Big Bend, of Florida, as having very high potential for site presence and preservation. This conclusion was later demonstrated to be the case (Dunbar *et al*. 1992; Faught 1996). Currently, and with National Oceanic and Atmospheric Administration (NOAA) funding, Adovasio and Hemmings (2010) are in the third year of a multi-year project to remote sense and investigate by diving, sites in the Big Bend area. The Coastal Environments Inc. 1977 Survey is an excellent example of how geology, sea-level rise, and culture history need to be combined and synthesized in order to characterize potential, bottom and sub-bottom morphology, and thereby to know the palaeolandscape and places to test for sites.

Follow-up MMS projects conducted by Coastal Environments Inc. in the 1980s included development of terrestrial analogues and criteria for finding and recognizing archaeological sites in the western Gulf of Mexico (Gagliano *et al*. 1982), and sub-bottom profiling and vibracoring to test for sites offshore in the Palaeo-Sabine River (Pearson *et al*. 1986, 1989; Stright 1986). Two probable archaeological sites were identified on terrace surfaces near tributary channel margins of the Palaeo-Sabine, now located under more than 4.5 m of sediment, 12 m underwater, and almost 13 km offshore. The remains were observed in multiple cores. One exhibited significant amounts of organics, phosphates, fine lithic debris, and burnt bone (dating to *c*. 8000 BP/6900 cal BC), consistent with criteria developed for recognizing a site, and the other was a mound of shells considered by its reconstructed morphology to be a midden. Currently, MMS is funding research to test sub-bottom profiler targets that including probable shell middens and other kinds of features (Evans 2010). Federal protection of submerged prehistoric resources will come to our attention increasingly as more wind farms and other facilities are constructed offshore around the nation.

Surely Florida has produced more submerged prehistoric sites, and more evidence of prehistoric sites impacted by dredging, than any other state in the Union (Dunbar 1991; Dunbar *et al*. 1992; Watts *et al*. 2004). Tampa Bay, in particular, has produced frequent chipped stone artefacts in dredge spoil deposits dumped on land and found by local collectors (Goodyear and Warren 1972; Goodyear *et al*. 1983). These finds include diagnostic pieces indicating Late Pleistocene (Paleoindian), Early Holocene (Early Archaic), and Middle Holocene (Middle Archaic) activity; the Middle Archaic lithics are the most frequent of these finds.

Recent research projects in Tampa Bay by Eckerd College, University of South Florida, and the U.S. Geological Survey have resulted in a more detailed understanding of the depositional history of the bay, and a palaeo-freshwater lake has been discovered in the upper bay with pollen and radiocarbon determinations from *c*. 18,000 cal BC to 11,500 cal BC that show local environmental progression, as well as global climatic indicators (Suthard 2005; Willard *et al*. 2007). This lake would have been a prime location for human activities and settlement.

Recent CRM projects in Florida have had some success in remote sensing, modelling site probabilities, and testing for sites or monitoring dredging activities. These CRM projects testing for submerged prehistoric sites, available from Florida's Master Site File and the senior author, were enabled because the Division of Historical Resources, Florida Department of State, is at the forefront of protecting submerged prehistoric

sites, just as they were at the forefront of protecting shipwrecks in the 1970s and 1980s. MMS has required sub-bottom profiling to assess for prehistoric sites since the 1980s, but Florida is the only state, so far, to require sub-bottom profiling in local underwater CRM projects.

That Florida is the only state that requires CRM attention to submerged prehistoric sites is disturbing, as virtually all states along the East Coast have exhibited evidence for submerged prehistoric sites. For instance, and for decades, fishermen, clammers, and shrimpers have recovered artefacts offshore or in Chesapeake Bay through dragging and dredging the seabed (Stright 1995; Blanton 1996). More recently, artefact discoveries from dredge spoil and beach replenishment have brought the presence and probability of offshore prehistoric sites to the attention of researchers (Crock 1993; Blanton 1996; Watts *et al.* 2004; Merwin 2006; Claesson *et al.* 2010). Geoarchaeological research by Leach and Belknap (2007) in Maine has compared the characteristics of submerged middens with submerged and buried oyster beds, and of benefit to the archaeologist is that substantial research has been conducted on the East Coast of North America by marine geologists and geophysicists, including sub-bottom profiling and multibeam reconstructing of palaeochannel systems, sand wave forms, and other sedimentary features (cf. Coleman and McBride 2008).

Not all the known submerged prehistoric sites are in marine waters. Sites include those in freshwater settings in Central America, such as lakes, and karst cenotes and cave systems. Some of the oldest examples of submerged prehistoric archaeology anywhere in the world were Thompson's brass helmet dives in Chichen Itza, on the Yucatan Peninsula (Andrews and Corletta 1995). In Central America there are cenotes and cave systems, as well as lakes, throughout the region with ceremonially deposited remains. Recent work in the karst caves of Yucatan, discovering human remains, and evidence for 9000 cal BC human remains has pushed the archaeological record back thousands of years in that region (Gonzalez *et al.* 2008).

McKillop (2005) has conducted very shallow water (<2 m) operations in Belize that have mapped and exposed massive salt production facilities with preservation that conforms to the potential of underwater conditions. She has documented numerous structures (indicated by postholes), wooden items, ceramics, and a wooden paddle. No boats, save small examples of dugouts from Mexico City, have ever been found in Meso-America, even though it is clear that the Maya and other culture groups had substantial maritime transit and trade at the time of Contact. Thus, the paddles found at K'ak' Naab', southern Belize, are very rare finds.

In Florida, the well-known Warm Mineral and Little Salt Springs karst cenotes are good examples of freshwater inundated prehistoric materials (Clausen *et al.* 1975, 1979). Page–Ladson, one of the oldest sites in the Americas, is an example of a sediment bank with terrestrially exposed and culturally altered levels preserved in the karst Aucilla River (Dunbar 1991, 2006; Latvis and Quitmeyer 2006). In addition, Page–Ladson is a repository of Late Pleistocene fauna in sealed beds and provides a record of pollen and macrofossils from Late Pleistocene to Late Holocene times (Webb 2006). Finally, a NOAA and NSF funded project in the Great Lakes has used multibeam bathymetry to reconstruct the bottom morphology, and known lake level fluctuations to show the configuration of the landscape in Paleoindian (Late Pleistocene) times. Diving explorations are planned (O'Shea and Meadows 2009; cf. Coleman 2008).

Two bays with underwater prehistoric sites: Apalachee and Ballena

Next, we talk about two projects that have had success at finding submerged prehistoric sites underwater, one in the Gulf of Mexico and one in the Gulf of California. They are located in different environments, with differing geologies and differing culture histories onshore, but with similar sea-level rise profiles and palaeolandscape settings. Both projects are conducted in exposed and shallowly buried submerged settings, which allow for simplified reconstruction of the palaeolandscape using bathymetry, as well as access to sites by SCUBA divers. We approached our projects with similar principles and ended up with some similar, and some different technical approaches. However, both projects focus on the benefits of finding and working in environments with archaeological and geoarchaeological potential in exposed and shallowly buried settings.

Apalachee Bay

One experience that seems to be shared by archaeologists looking for submerged archae-

ological sites is the realization of the immensity of the ocean, the transformation of a terrestrial exposed landscape to a dynamic seabed, and the smallness of the artefacts we are looking for in that medium. Finding a submerged prehistoric site underwater is, perhaps, more difficult than finding the 'needle in the haystack'.

In 1986, as a PhD dissertation project, Faught chose to find submerged prehistoric sites by identifying areas with 'overlapping potential' to increase the likelihood of discovery and to develop a sustained approach. This began with a literature survey to identify regions in North America with low-energy marine environments that enable preservation of submerged archaeological material, low sediment cover to allow for diver access to artefacts, and high numbers of early sites (i.e. artefacts) onshore, to increase the likelihood that remains could be found on the submerged landscape (cf. CEI 1977; Pearson *et al.* 1986; Stright 1995; Faught 1996: 270–94).

Florida's western continental shelf was known to have a low slope and relatively moderate- to low-energy marine environment and coastline, both factors that encourage relatively rapid transgression and potential for sedimentary preservation, particularly in karst 'voids' (CEI 1977; Faught 1996). Karst voids as used here describe sinkhole-like features of various sizes and shapes eroded in the basal limestone. The continental shelf off Florida is a stable platform, with recorded depths and environments of deposition indicative of sea-level rise (Ballard and Uchupi 1970; Faught and Donoghue 1997; Balsille and Donoghue 2004). However, even with these factors to guide the research, the continental shelf remained a vast, unknown submerged palaeolandscape.

It was therefore important to consider the known archaeological patterning that existed onshore. In the Big Bend area, archaeological sites were known to occur by karstic river channels and their margins, and rock outcrops that were used as chert quarries (Dunbar 1991). As these karst features are known to retain much of their physiography when found in a submerged environment, rocky outcrops and karstic palaeochannel vestiges were targeted for diver survey. As there is little to no sediment yield from rivers in karst areas, the palaeolandscape near these rivers can be exposed or shallowly buried locally, and therefore accessible by divers. These favourable attributes that existed in the Big Bend area made it a logical locale to begin exploration (Fig. 12.2). To target the palaeochannel and rocky outcrop features, the bathymetry of the area was digitized and contoured from navigation maps. This allowed for identification of apparent channel 'thalwegs' (defined here as the line connecting the lowest points along the length of a channel) and their margins, based on deeper channel-like features (Fig. 12.3).

By narrowing the vast landscape down to this one region, and to specific features of the seascape, a predictive model of areas that were likely to contain archaeological material was developed and tested. Survey began with small

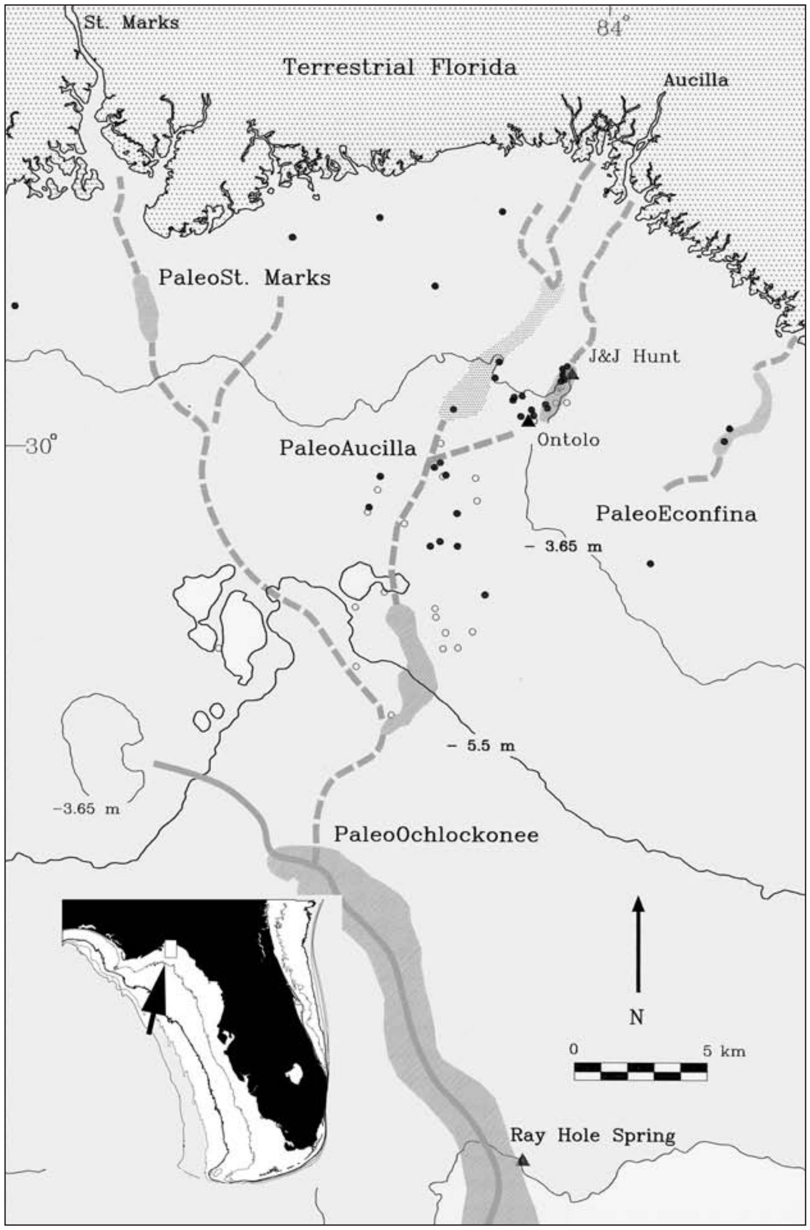

Figure 12.2: Study area for research in the Big Bend, showing the location in the Florida Peninsula (inset), as well as palaeolandscape features, locations of submerged sites (filled circles and triangles), and locations where sites were not found during survey (open circles)

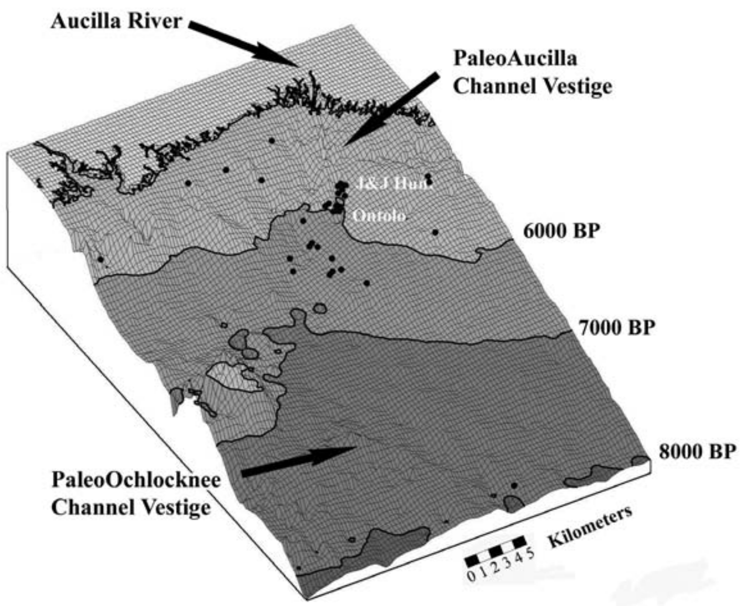

Figure 12.3: Initial reconstruction of the local bathymetry enhanced by 500 per cent vertical and displayed as a mesh diagram showing palaeochannels and other features of the palaeolandscape. Dates in radiocarbon years.

boat forays of SCUBA diving and snorkelling, from both the Econfina and Aucilla rivers, utilizing a variety of methods (study of navigation map features, towing divers, and hand fanning potential sites). These initial forays resulted in recovery of chipped stone artefacts, some characteristic of the Middle Holocene, associated with rocky outcrops along channel margins. As the Aucilla River was known as the prime collecting location in Florida for early fluted (Clovis) points, and because the J&J Hunt site was discovered along its margins, the Palaeo-Aucilla River was targeted for sustained research (Faught 1988, 1996; Dunbar *et al.* 1992).

Once the Apalachee Bay was known to contain preserved, diagnostic cultural materials, more funding could be obtained by grant writing. This research culminated with a field school in underwater archaeology funded by the Florida Department of State, Division of Historical Resources. This field school collected remotely sensed data using side-scan sonar (able to identify rocky outcrops and channel margins when exposed) and a sub-bottom profiler (allowing reconstruction of bottom bathymetry, buried palaeochannels, and identification of various sediment beds). In addition, multiple excavation and mapping crews operated from 15–18 m vessels for extended periods of time offshore. Remote sensing surveys logged more than 500 linear km of survey lines, and diver investigations were conducted at 52 locations targeted by the initial research. Thirty-six of these locations were positive for preserved cultural material. Of these, five sites were sampled using 10 and 15 cm induction dredges (Fig. 12.4), with most sampling occurring at the J&J Hunt and Ontolo sites (Marks and Faught 2003; Faught 2004).

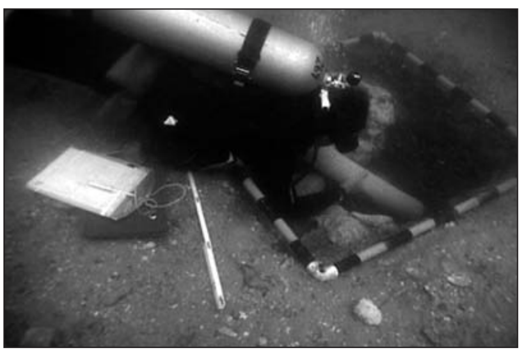

Figure 12.4: Diver excavating the margins of the Palaeo-Aucilla River with a 15 cm induction dredge the slurry from which was screened from a floating screen deck

The resulting sample from survey, collection, and testing operations of the *PaleoAucilla Prehistory Project* is well over 4500 pieces of chipped stone, including diagnostic projectile points of Late Pleistocene to Middle Holocene age (Fig. 12.5), formal chipped stone tools, and abundant debitage, as well as a rough reconstruction of site types for the segment of the Palaeo-Aucilla River studied (Faught 2004). In addition, a significant amount of animal bone, including both extinct and extant species, has been found at these sites – particularly at J&J Hunt – and unaltered wood, mollusc, and sediment samples complete the collections. A final report is forthcoming, but there are three summary publications (Faught 1996, 2002, 2004), a Master's thesis (Arbuthnot 2002), and a PhD dissertation (Marks 2006), as well as several interim reports (http://www.flheritage.com/archaeology/underwater/fsu_pua/).

Bahía Ballena

As mentioned above, it is integral to underwater research to locate an area with high preservation potential. Along the Pacific Coast, numerous areas in the Gulf of California exhibit characteristics that are ideal for submerged archaeological research. One such area is the submerged landscape off of Isla Espíritu Santo, Bahía Ballena, in the southern Gulf of California (Fig. 12.6). The geographical, geological, environmental, and cultural characteristics of this region combine to present an area with significant archaeological potential.

Culturally, this area has a known, prolonged, occupational history that extends from the Late

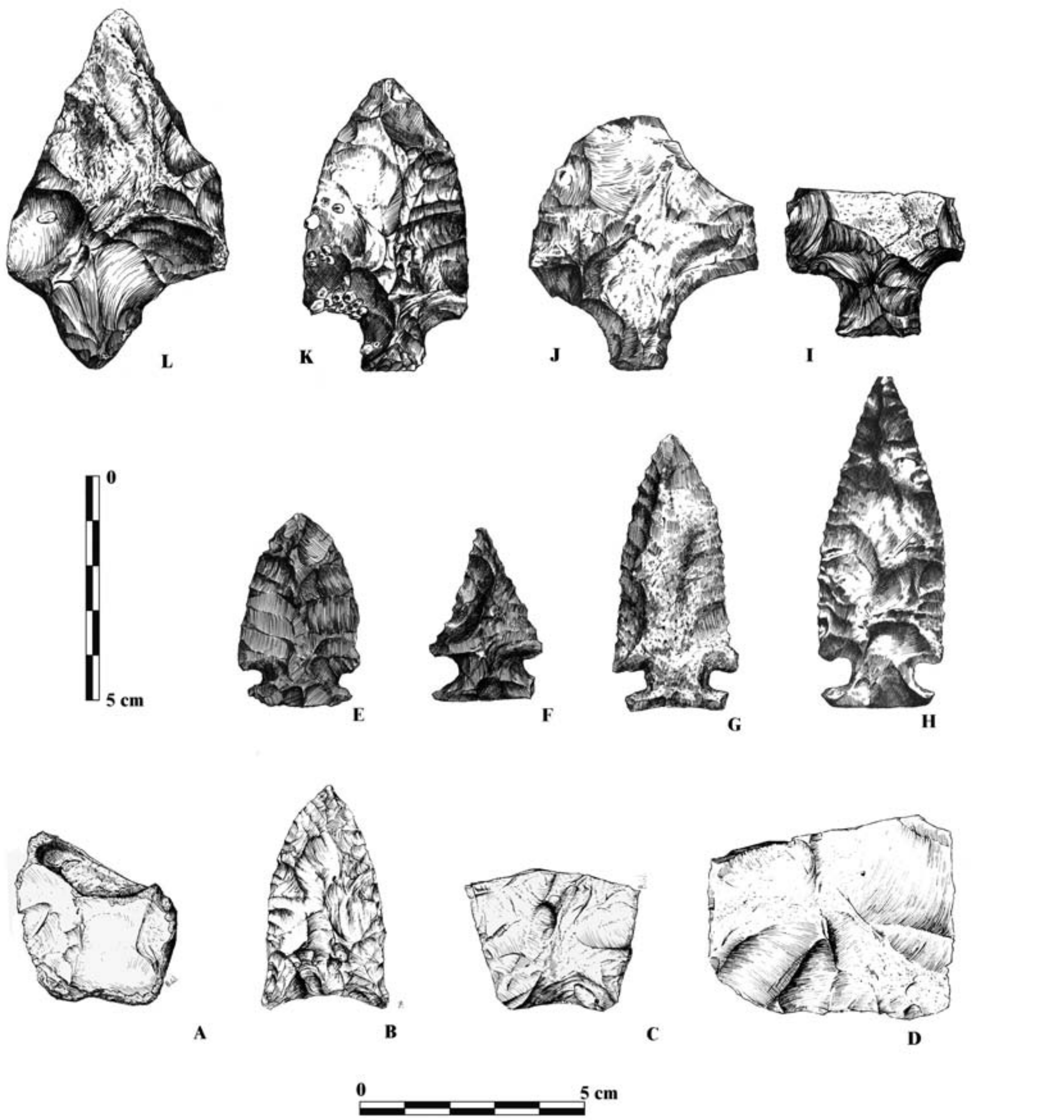

Figure 12.5: Diagnostic artefacts from the Palaeo-Aucilla River research, most from J&J Hunt. A–D Paleoindian diagnostics (including probable fluted point, A), E–H Early Archaic diagnostics, and the remainder Middle Archaic points characteristic of Middle Holocene cultures in Florida

Pleistocene through to the Historic Period. Throughout this entire occupation span, the groups that inhabited this region made extensive use of the abundant rockshelters present in the soft volcanoclastic rock that forms much of the geological make-up of Isla Espíritu Santo. When considering where to conduct underwater work, an area with archaeologically identified rock-shelter use can be considered extremely favourable. In a submerged environment, the area inside a rockshelter can provide an enclave in which any cultural material present may be protected from tidal and wave action and, therefore, have a higher probability of preservation than open-air archaeological material exposed to shoreface erosion.

Environmentally, the coast of Baja California is generally rich in marine resources, an important consideration for groups migrating along a coastal route. Although marine productivity in Baja California was 'drastically lower during past cool stadials and the Last Glacial Maximum than it was during the Holocene and past warm episodes' (Ortiz *et al.* 2004: 523), the littoral and nearshore environments of Isla Espíritu Santo could have supported the small groups thought to comprise the New World Pleistocene palaeocoastal population. Identifying evidence of these smaller groups on the now submerged palaeolandscape is facilitated by the geographical characteristics of the island and surrounding waters. Isla Espíritu Santo dips to the west and

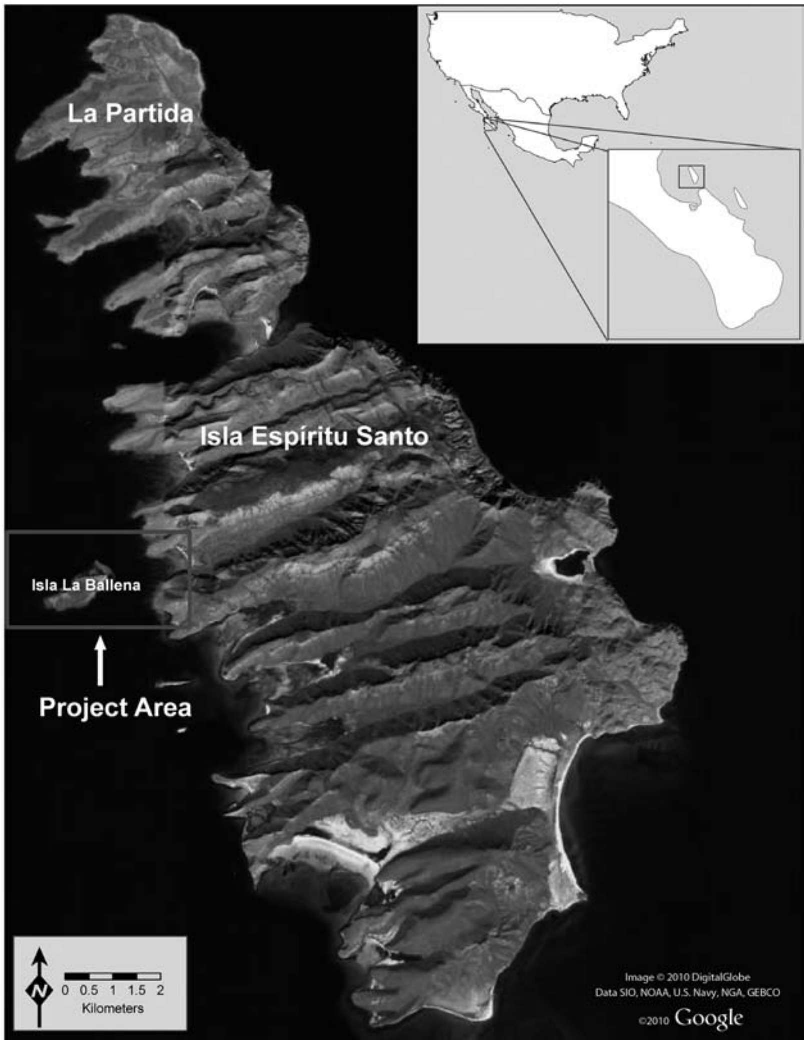

Figure 12.6: Location map of Isla Espíritu Santo and Isla La Ballena

the resulting structural context is one of shallows bays with gently sloping nearshore bathymetry. This bathymetry promotes preservation of inundated archaeological deposits in nearshore open-air contexts as site disturbance can be mitigated by the rapid sedimentation that can occur on a slope during sea-level rise.

The unique oceanographic and geological conditions that exist in this locale allowed for a simplified method of bathymetric data collection and creation of a palaeolandscape model. Over a period of two weeks, a team of researchers logged a total of *c.* 35 hours on a bathymetric survey of 30 km^2. The survey was conducted in a small boat (*c.* 6 m in length) that slowly traversed back and forth across the entirety of the one of the shallow bays off Isla Espíritu Santo and the waters directly outside the bay. Once beyond the points of the bay, the survey continued to -80 m in a north–south trajectory and to -140 m to the east beyond La Ballena Island.

To collect the bathymetric data a Garmin GPS 76 unit was used to record horizontal position, and a consumer fathometer, also called a 'fishfinder', was used to measure depth to the seafloor. A total of 2145 depth readings with corresponding UTM coordinates were logged in a notebook each time the depth reading changed by approximately 1.5 m, or in areas of rapid seafloor descent or ascent. Although this method for obtaining seafloor morphology is not as precise as a swath bathymetric system, it provided a highly cost-effective means of identifying larger geomorphic features that might be associated with submerged sites, including rock outcrops, terraces, and palaeochannels.

In order to utilize the bathymetric data to create a palaeolandscape model, the data were imported into ArcGIS 9 and integrated with temporal sea-level elevation data. This allowed the creation of a digital elevation model (DEM) of the submerged landscape by using an interpolation technique called Inverse Distance Weighting (IDW). This method is a lattice-based algorithm that calculates the unknown Z-value for each cell missing elevation data by assigning a weighted average based on a minimum number (typically n=12) of surrounding Z-values (Hageman and Bennett 2000: 116) (Fig. 12.7).

Much of the additional data required for modelling efforts within GIS is accessible through government agencies via the Internet. For the research area, satellite imagery of Isla Espíritu Santo was acquired from the freeware software program, Google Earth, and topographic data for Isla Espíritu Santo were acquired from the Shuttle Radar Topography Mission (SRTM). The Google Earth image was georeferenced using latitude and longitude lines, and the SRTM image was already embedded with spatial information upon receipt. By merging the SRTM of the terrestrial landscape and the DEM of the submerged landscape, the ArcGIS software could consider them one seamless surface and create a visual representation of the palaeolandscape at 12,000 cal BP (Fig. 12.7).

Using existing knowledge of archaeological site distribution from surveys of the modern terrestrial landscape (Fujita and Poyatos de Paz 1998), we made predictions about the distribution of palaeoenvironmental features that might have attracted early hunter-gatherers, and

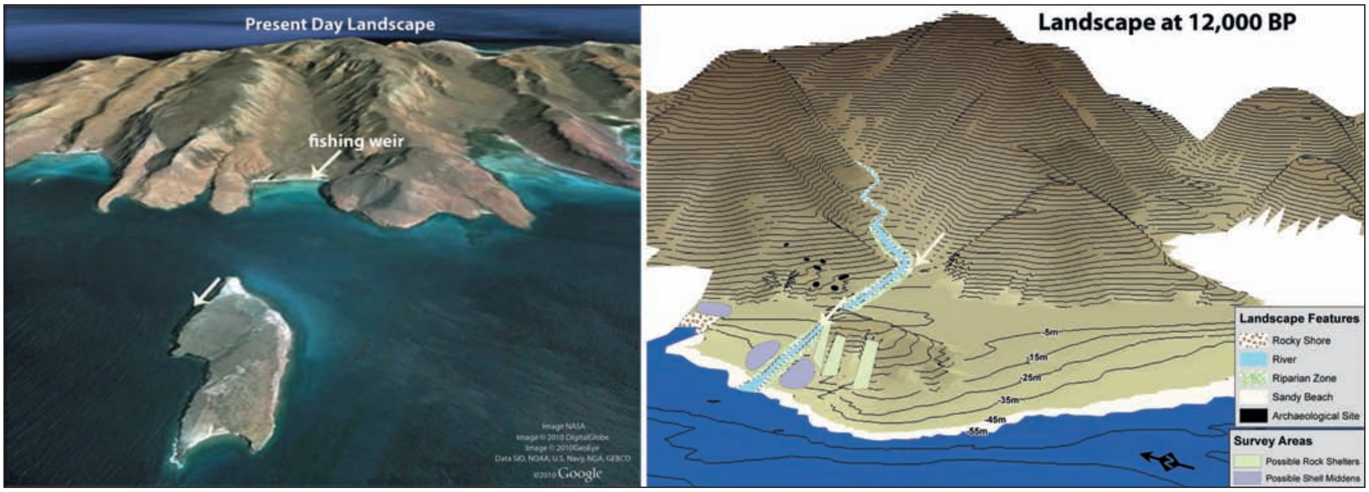

Figure 12.7: Palaeolandscape model of topographic and environmental features, and locations of known archaeological sites. Left – present landscape off the western margin of Isla Espíritu Santo; arrow on shore indicates location of prehistoric fishing weir; arrow by smaller island indicates location of caves investigated. Right – configuration at 12,000 cal BP, showing currently submerged palaeolandscape and palaeoenvironmental features, as well as areas targeted for survey. These survey areas were targeted owing to the possibility that rockshelters and/or shell middens would be present

subsequently retained archaeological evidence of occupation. Any survey plan developed from this approach must take into account the methods that will be used for further landscape exploration. Our research was focused on nearshore, relatively shallow locales that could be adequately explored using conventional SCUBA equipment.

Development of a survey plan based on the palaeolandscape model narrowed search areas to those most likely to have preserved evidence of past cultural use. By targeting locales with features that might include rockshelters, rock outcrops, and palaeochannels, we were able to create project goals that were achievable in the time designated for underwater survey. Areas with strong current or no prominent topographic features were immediately taken out of consideration for survey in order to focus time and resources on those areas considered favourable for preservation.

The underwater investigation began with a number of reconnaissance dives intended to collect data, such as sediment type, features present, and feasible dive times for the areas highlighted with the palaeolandscape model. This allowed for further culling of any area that did not meet our criteria for a locale with high archaeological and preservation potential. At the end of the reconnaissance phase, survey areas were limited to four submerged rockshelters, the areas outside the mouths of each of the rock-shelters, an area with extensive rock outcrops, and one steep slope (Fig. 12.7). These areas were highlighted as features that might contain evidence of past human use, specifically shell middens or lithic scatters.

Although, originally, survey efforts were focused on the interior of the rockshelters, it was quickly determined that all lithic material located inside and directly outside the submerged rockshelters was abraded owing to tidal action. This made identification of culturally flaked material impossible, and we therefore shifted our survey focus to the rock outcrop locales, and to determining the amount of sediment cover that had accumulated over the terrestrial landscape. The area chosen for this work was 18–20 m in depth, downslope from a rockshelter, and next to a modelled palaeochannel. By hand fanning test pits that extended approximately 80 cm below the seafloor, we were able to identify numerous depositional episodes within each test unit, a shell deposit within one test unit, and lithic material that is currently being analyzed for evidence of cultural modification.

The issue of identifying artefacts from geofacts within the Baja California Sur region is difficult and in need of disciplined criteria developed for determination. Likewise, in many submerged situations, immediate recognition of an archaeological site that has been altered by transgression and submergence is not always forthcoming and criteria for determination of a site are needed for local situations (Gagliano *et al*. 1982). This Baja California research is making strides to understand the processes that have occurred in the region over the last 13,000 years, and how these affect material identified in a submerged setting. While this will be an on-going process, the immediate contribution of the present research is methodological. The fact that a paleolandscape model was developed using simplified and inexpensive methods, and this

model was accurate enough to reconstruct the locations of rockshelters, a palaeostream channel and possible shell midden locales, contributes to the methodological development of prehistoric underwater archaeology in the Americas (Gusick and Davis 2007).

Conclusions

Our experiences have shown that exposed and shallow-buried palaeolandscapes enable the discovery of submerged prehistoric sites, as well as information about where to go in more deeply buried and possibly better-preserved situations. The principles that provided the framework for our projects described above include knowing culture histories, understanding regional sea-level histories, identifying geoarchaeological preservation potential, developing predictive models based on the synthesis of these factors, and, most importantly, diving and digging to test them (Gusick and Faught, in press).

These examples also demonstrate that low-tech, lower-cost operations are often useful to lay the groundwork for obtaining additional and sustainable resources, but that higher-cost methods are by far preferable to assess and investigate offshore settings, and will be so for buried and truncated palaeolandscape settings. In particular, sub-bottom profiling to reconstruct channel configurations, and coring or excavating to test sediments deemed probable for sites, have proven effective methodologies at Hecate Strait, British Columbia, and at the Palaeo-Sabine River, in the Gulf of Mexico (Stright 1986; Easton and Moore 1991; Josenhans *et al.* 1997). The research in Apalachee Bay reported here has benefited substantially from channel configuration mapping with sub-bottom profiling (Faught 1996; Faught and Donoghue 1997) and the next phase of research in Baja California has been funded by NOAA's *Ocean Exploration program* and will include remote sensing operations with sub-bottom profiler and side-scan sonar devices. In fact, it is developments in underwater technologies, such as GPS locational control, sound underwater imagery, and seismic remote sensing that will enable underwater prehistoric archaeological research to come into its own in the 21st century in the Americas.

Today, the need for American researchers to have expanded settlement pattern data and procedures for remote sensing and testing in different coastal situations is increasing. Recent NOAA and MMS funding for research specific to palaeolandscape exploration and testing targets identified with remote sensing has enabled several important exploration and research projects to be undertaken, which will bear fruit in future publications. Furthermore, in areas with large expanses of continental shelf such as the Eastern Seaboard or the Gulf of Mexico, cultural resource managers charged with protecting submerged prehistoric sites are becoming more aware that there are settlement systems preserved offshore. Although protected by law, these are in danger of destruction by the increasing number of industrial and developmental projects conducted in near- and offshore settings. Threats can be addressed by cooperative projects with industries capable of large-scale, high-precision manipulation of remote sensing gear and bottom sediment excavation and processing (Faught and Flemming 2008).

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13

Underwater Investigations in Northwest Russia: lacustrine archaeology of Neolithic pile dwellings

Andrey Mazurkevich and Ekaterina Dolbunova

Many sites that originally were located on the shores of lakes in northwestern Russia now lie in peat bogs or are underwater. Many of these sites can only be investigated by underwater archaeology. The first underwater excavations were those undertaken in 1979 by the late A. Miklyaev on Lake Sennica in Pskov province. Further investigations were conducted in lakes in Pskov and Smolensk provinces and in the Western Dvina River. Pile dwellings appeared in this region c. *3200 cal BC, and GIS modelling has shown that they were located on islands. The pile dwelling settlements were situated at the boundary between different landscape types that provided the basis of a productive hunting and gathering economy, and remained the typical settlement pattern for over a millennium. The economy of the builders of the pile settlements was complex with the prevalence of an extractive strategy, in which hunting took precedence over fishing and gathering. We have also traced the initial stage of pig domestication in this region, and the spread of agriculture was marked by the appearance, at the beginning of the Subboreal, of the pollen of culturally introduced cereals. The introduction of farming led to population expansion, which is reflected by an increase in the number of dwelling structures at the site of Serteya II. One reason for the construction of pile dwellings may be that the Neolithic builders wanted to keep free those areas suitable for agriculture and cattle herding.*

Keywords: pile dwellings, Neolithic, northwest Russia, underwater archaeology

History of investigation

The first underwater investigations in northwestern Russia (Fig. 13.1) were undertaken in 1979 in Lake Sennitsa (Pskov province). Sites were revealed after the water level was lowered artificially. Eight multi-layer settlements were investigated, which produced archaeological remains ranging in age from Mesolithic to early Medieval (Miklyaev 1990; Miklyaev *et al*. 1993; Mazurkevich *et al*. 2005). The focus of this chapter is on the Stone Age evidence. In 1972 during the exploration of the small River Serteyka (Western Dvina River, in the Smolensk region) the settlement of Serteya II was discovered (Fig. 13.2). Excavations in 1973 showed that it would be most effective to investigate this site using underwater archaeological methods. The discovery of sites of this type was not unexpected since pile dwellings had previously been found in peat bog layers, which were investigated in 1963 by Miklyaev. Methods adapted to high quality conditions of preservation were required to excavate these underwater sites. Furthermore, investigating these sites demanded the reconstruction of the ancient environment. This complex approach initiated in the 1960s by Miklyaev (1969, 1971, 1995) included the application of archaeological as well as natural scientific methods (geomorphology, palynology,

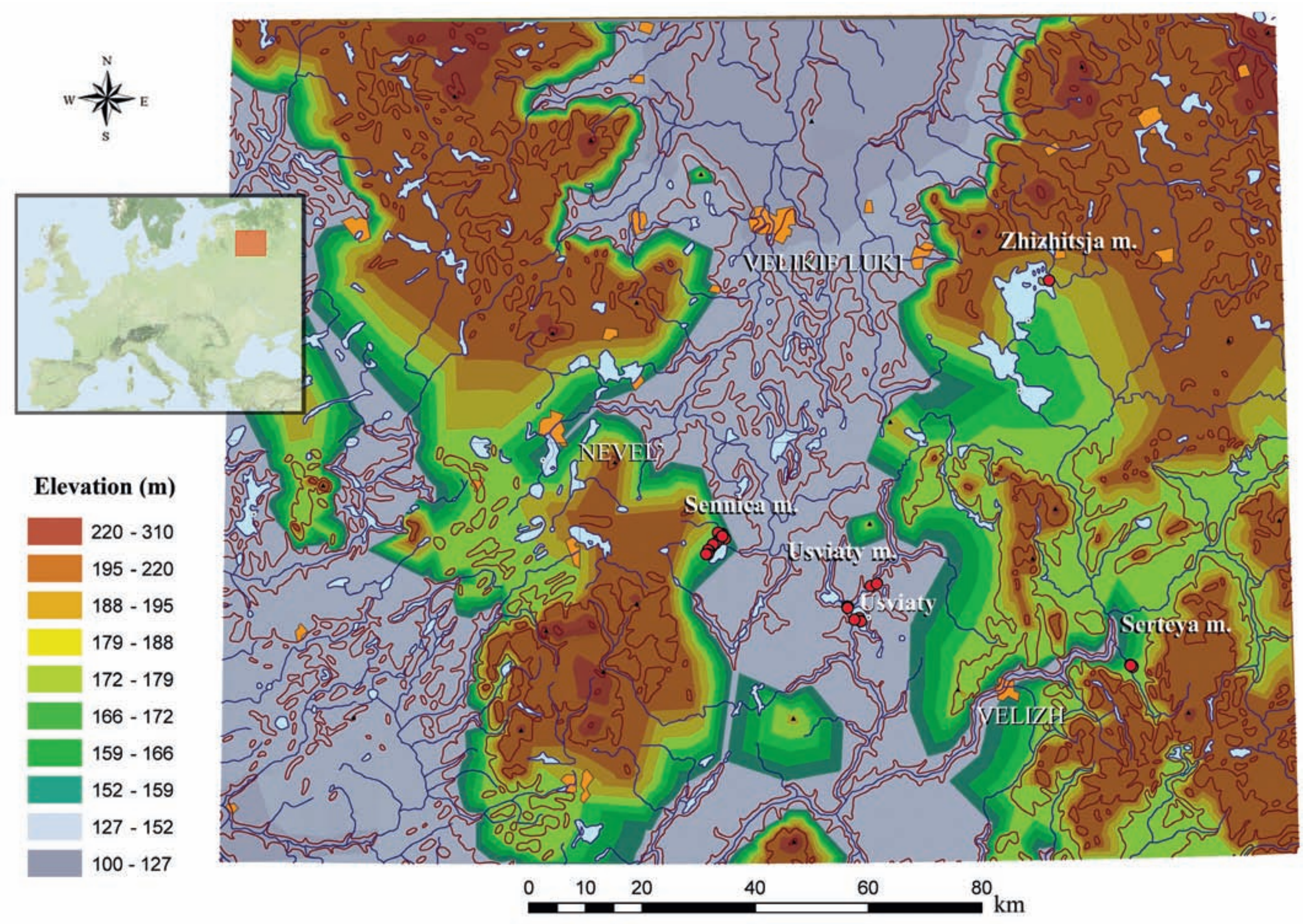

Figure 13.1 (top): The distribution of pile dwellings in northwestern Russia

Figure 13.2: (bottom) View of the Serteya II site

radiocarbon dating, diatom analysis, and palaeozoology) and GIS technology.

Methods of underwater excavation

Underwater excavation methods have been developed from our own experience (and that of our colleagues) for working under the following conditions, poor visibility (0.1–1.5 m), low water temperature (11–14°C) and shallow depths (0.7–3 m) (Miklyaev 1982, 1990; Mazurkevich *et al.* 2000), on the sites of Serteya II and Dubokrai I–XI. These circumstances dictate certain rules of diving; a diver should not only remain at the necessary depth during removal of material from a cultural layer, but should also attempt to remain motionless and not disturb silt so as to maintain good visibility. The first stage of work consists of the organization of a working platform for divers, preparation of a convenient approach to the water, gangway installation, clearing the excavation site of vegetation, and the removal of recently accumulated silt with a hand dredge. During underwater excavations the site area is marked out in a 2 m grid from a baseline situated on the shore. Our protocol for archaeological finds consists of describing an object, defining the limits of the object by washing out the sediment

Figure 13.3: Serteya II: underwater excavation in progress

from around it, recording the object's location by fixed-point triangulation, and reporting these data to the surface (Fig. 13.3). The data are noted in the field inventory, which is maintained by grid squares. A plan is made that shows the constructional remains of the pile dwellings and any associated material. Video and still photography are conducted in parallel. Organic objects are packed into polyethylene bags and raised to the surface. Pottery fragments and flints are put in a basket and raised to a surface after the completion of the diver's shift. Fixed piles and other constructional elements are marked by labels with numbers, which are attached underwater and marked on the site plan.

The clearing of the lake bed is also conducted by grid squares beginning downstream and going from deeper to shallower water progressively. The dredge is applied to create a more intense stream in order to remove debris. Removal of material from cultural layers is done by stripping with knives, or by hand fanning, or with a weak spurt from the pump where this can be more effective. Debris produced in the course of excavation is raised to the surface with the help of an ejector; it is then sieved, flushed with water, and examined several times.

Climatic conditions

Pile dwellings occur in several archaeological microregions: Serteya, Usvyaty, and Sennica (Fig. 13.1). The Serteya is a small tributary of the Western Dvina River, 20 km east of the town of Velizh and 100 km north-northwest of Smolensk, the provincial capital. This area lies immediately south of the limit of the Last (Valdai–Weichselian) Glaciation. The surrounding terrain forms an evenly undulating sandy glacial outwash plain at 150–180 m ASL, with isolated morainic landforms (Malakhovsky and Markov 1969). The Serteya's narrow valley widens out in two places, one in the north and one in the south. During the Holocene the entire valley contained lakes that were drained during the subsequent development of the Western Dvina catchment. Starting with the maximum advance of the Valdai ice sheet *c*. 20–18 ka BP, a system of ice-dammed lakes encompassed the entire catchment of the upper Western Dvina River (Kvasov 1975). Their shorelines are visible at heights of between 130 m and 180 m. The lakes were the result of the damming of the Baltic Sea basin by ice, and the system collapsed following the abrupt fall in the level of the Baltic Ice Lake (Agrell 1980; Andrén *et al*. 2002).

The first pile dwellings, which belong to the Usvyatian Culture, existed between 3700 and 2550 cal BC. Their appearance marks a cultural discontinuity, and coincides with a major change in the environment (Fig. 13.4). Diatom analysis indicates a fall in the level of the alkaline eutrophic lake reflecting a wider climatic trend (Dolukhanov *et al*. 2004; Arslanov *et al*. 2009). Pollen analysis shows considerable fluctuations of the main taxa, apparently reflecting anthropogenic impacts. This stage begins with a rapid decrease of *Betula* and the broad-leaved species *Ulmus*, *Quercus*, *Tilia* and *Corylus*, together with peaks of *Picea* and *Pinus*, and an increased frequency of herbs (Poaceae and Cyperaceae). Subsequently, there was an increase in the frequency of broad-leaved species *Ulmus*, *Quercus*, *Tilia* and *Corylus*, with a rise of *Betula* and *Alnus*, and a general increase of herbs (Poaceae and Cyperaceae) with the appearance of heliophytic herbs, *Artemisia* and Chenopodiaceae. This pattern, which repeats at least twice, suggests selective felling and subsequent regeneration of forests.

The lake bed was revealed by a fall in the water level. Settlements were transferred to the new, lower shoreline. Structures included platforms resting on posts thrust into the lake mud. In their construction *Picea*, *Pinus*, *Fraxinus*, *Acer* and, more rarely, *Quercus* were used. These pile dwellings were of a considerable size, in one case reaching 1000 m^2. Remarkably, similar structures appeared at that time in the wetland landscapes of various parts of Europe; they became most common in the Alpine zone (e.g. Schlichtherle

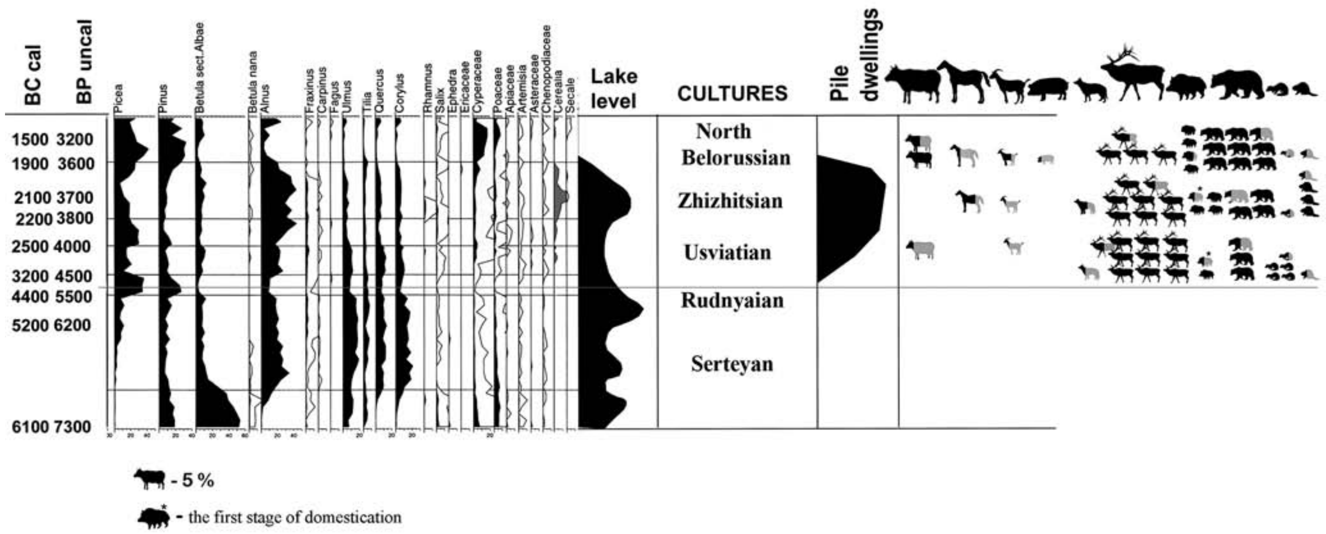

Figure 13.4: Synchronization of pollen diagram (After Dolukhanov et al. *2004) with radiocarbon dates, lake level data, faunal evidence, and archaeological cultures*

1997) but existed also in other areas, including Scandinavia (e.g. Göransson 1996).

The pile dwellings reached their maximum size during the next stage, which included the Zhizhitsian (2550–2250 cal BC) and North Belorussian (2250–1950 cal BC) cultures. This coincided with a new rise in lake level. Detailed excavations and statistical analyses have shown that each individual dwelling existed for less than 170 years, and each settlement included no more than two pile structures. Animal remains from North Belorussian Culture sites include a limited amount of domesticated animals, cattle (*Bos taurus*), sheep/goat (Ovicapridae), and pig (Suidae). The same levels show the highest frequencies of Cerealia and the appearance of weeds (notably *Plantago lanceolata*) and apophytes. All this is a clear signal of increased impact on the landscape by these early agriculturalists.

Peculiarities of pile dwellings: location and economy

Pile dwellings appeared at the Atlantic/Subboreal boundary (3700–3200 cal BC) when there was a regression stage of lakes. As shown by pollen analysis, the end of the Atlantic period coincided with the maximum extent of broad-leaved species, mainly restricted to the endmorainic uplands. However, the fall of temperature that began in the Subboreal period caused a decrease of broad-leaved species and an increase of spruce (*Picea*). At that time pile dwellings also appeared in southern Germany and Switzerland in a similar landscape; they were situated on lake shores located in front of the morainic formations of the Würm Glaciation (Pétrequin and Pétrequin 1988; Dolukhanov and Mazurkevich 2000).

Spatial analysis of lacustrine pile dwellings in the study area reveals a clear subsistence pattern based on catchment area, which limits foraging to a two-hour walking distance (*c*. 10 km) from the central hunting lodge (Zvelebil 1996). The settlement and the zone of economic activity are regarded as one natural–economic complex. It determines the boundaries of the economically favourable landscape surrounding the settlement, which allows us to estimate the extent and types of natural resources used by ancient people. It allows the reconstruction of the peculiarities of the economy and an estimation of the demographic situation of this area. The catchment area of the pile dwellings includes three distinct landscape types: (i) lake plus low-lying terraces and offshore mires; (ii) endmorainic formations with predominantly clayey soils covered by broad-leaved trees; and (iii) glaciofluvial outwash plains with sandy, podzolic soils covered with pine forests (Dolukhanov and Miklyaev 1986). The combination of these types of landscape made possible a productive hunter-gatherer economy and strongly contributed to the settlement system at this time (Dolukhanov and Miklyaev 1986). Only specific types of landscape were chosen for settlement, whereas the rest of the region was uninhabited. It also explains the long duration of pile dwellings in one place.

Interesting results have also been acquired from GIS-modelling of Lake Sennica (Pskov region) where sites are only situated on the western and northern side of the lake basin. Poor natural light on the eastern and southern shores, particularly in winter, as well as exposure to strong northerly winds and maximum remoteness from broad-leaved forests, all contributed to making these locations inconvenient for inhabitation. Furthermore, several former lake basins were made visible by remote sensing and analysis of sediments from boreholes made in the middle of these palaeolacustrine features. There are several ancient small lake basins joined by channels near the western and northern shores, which are separated from the central lakes by islands where the sites are situated (Mazurkevich *et al*. 2005).

The faunal and botanical records indicate that the Usvyatian lake dwellers relied heavily on wild resources, with year-round procurement of meat and fur animals as well as fishing. The majority of bones found on the pile dwellings belonged to elk (*Alces alces*), with fewer examples coming from bear (*Ursus arctos*), boar (*Sus scrofa*), hare (*Lepus timidus*), sable (*Martes zibellina*), marten (*Martes martes*), otter (*Lutra lutra*), beaver (*Castor fiber*), wolf (*Canis lupus*), roe deer (*Capreolus capreolus*), and mink (*Mustela lutreola*) (Fig. 13.4). These animals represent a complex of species adapted to life in broad-leaved and mixed forests (Kuz'mina 2003). Judging from the age groups identified, elk was hunted throughout the year. Whole carcasses of large animals were brought to the sites where butchering was done. Evidence for this is provided by kitchen debris including a large number of non-edible parts of the animal (e.g. hooves, teeth, and caudal vertebrae) represented in the faunal remains. Absence of antler fragments could be the mark of utilization of this material for tools. The number of fish bones recovered indicates the considerable economic significance of fishing. There are bones of large catfish (*Silurus glanis*), pike (*Esox lucius*), perch (*Perca fluviatilis*), zander (*Stizostedion lucioperca*), as well as small fishes. Birds were also hunted. Hunting for upland fowl (wood grouse, black grouse, and white partridge) was conducted mainly in autumn and winter by noose snares, and in warmer seasons projectiles were used to take natatorial game (e.g. goose, duck, and swan – Sablin and Siromyatnikova 2009: 153–5). Food gathering was of considerable significance as well; a considerable quantity of shells from nuts and acorns were recovered, as were cockleshells from the lake. At least 30 edible wild plants were used for food. Processed hazelnut (*Corylus*) and water chestnut (*Trapa natans*) became the surrogate of bread and the main source of plant protein.

The economy of the pile dwellers had a complex character; hunting prevailed over fishing and food gathering. Some wild boar (*Sus scrofa fer.*) caught in the course of hunting were not killed immediately but were kept for some time on several sites, and these animals were fed with fish. This is evident from the analysis of pig faeces containing small fish bones and scales, which were found in the base of cultural layers. Thus, we observe the apparent initial stage of pig domestication with 'no evidence of pig rearing given the bones of piglets less than three months old were found. Further, formal pig keeping would have immediately resulted in a reduction of the animals' size, yet all the boars identified at pile dwellings were exclusively large-size individuals' (Sablin and Syromjatnikova 2009: 155). This happened under the influence of the Globular Amphora and Funnel Beaker cultures, which can be clearly traced through the pottery typology of this time (Fig. 13.5). Furthermore, bones of already domesticated pig (*Sus scrofa dom.*) and bones of a cow (*Bos taurus*) and a dog (*Canis familiaris*) have been found on the site of Usviaty IV dating to the end of 4th millennium cal BC (Sablin and Siromyatnikova 2009: 155). Teeth of a horse were found on the site of Serteya XI dating to the beginning of 3rd millennium cal BC. Their small size and thin, weak enamel indicate that these teeth belonged to an old domesticated horse (*Equus caballus* – Kuz'mina 2003: 305).

Traces of agriculture are observed in the early Subboreal (SB-1) period. However, judging from the palynological data, this was not the first evidence of agriculture. However, all previous 'attempts' at farming had no continuity; agriculture was not adopted or was not continuously employed in the local environment. Thus, the first stable appearance of Cerealia in the pollen record is dated to the beginning of the Subboreal. A high content of grassy vegetation is shown in the pollen diagram for the same period, which marks the expansion of open spaces that could have been used by prehistoric people for agriculture and cattle herding. Ethnographic evidence shows that in northern Russia, Finland, and Karelia 'burn clearings' were cultivated on sloping and hilly

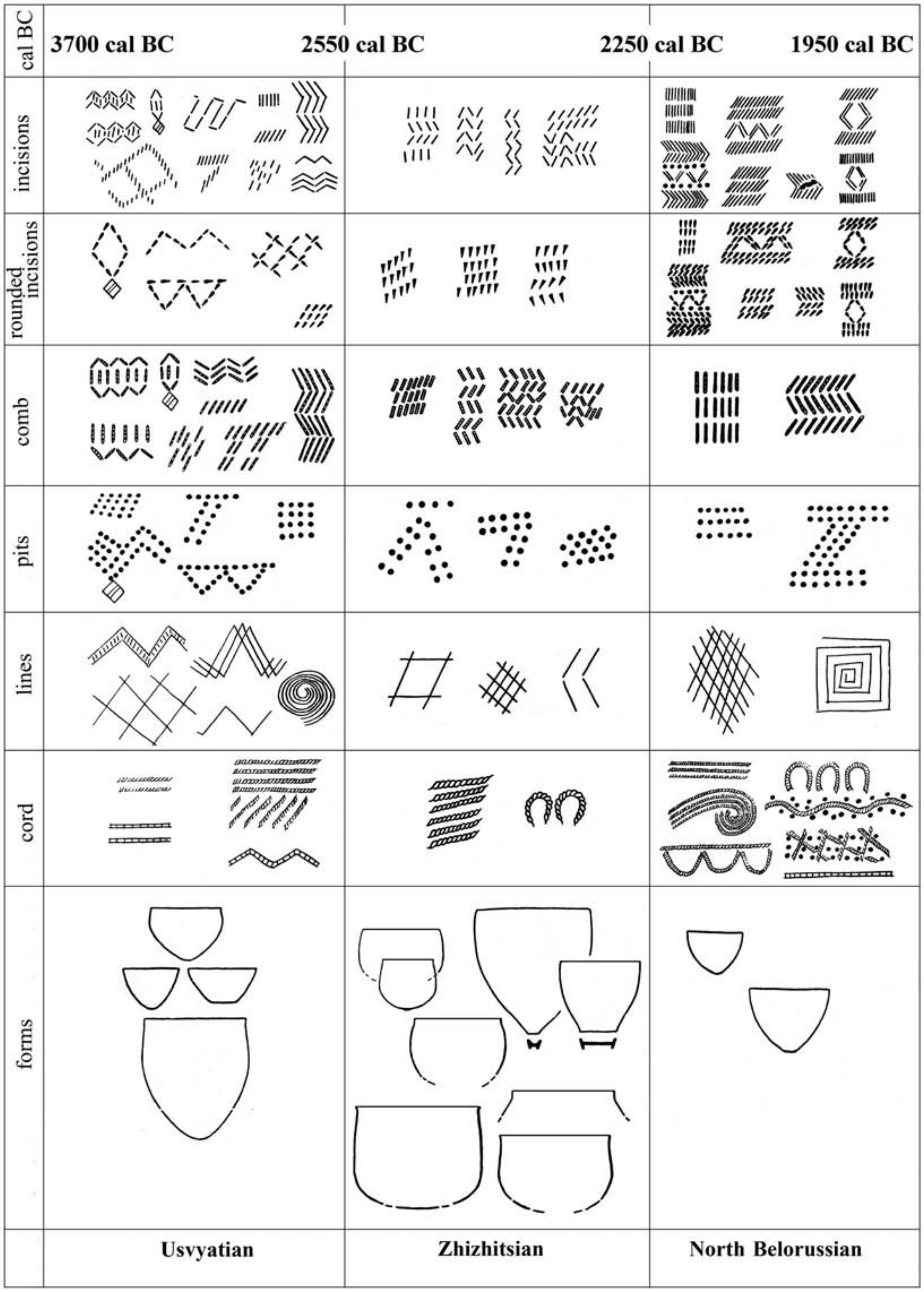

Figure 13.5: Scheme of development of decorative motifs and vessel forms of pile dwelling cultures between 3700 and 1950 cal BC (After Miklyaev 1969; Miklyaev and Semenov 1979)

terrain (Petrov 1968). In the case of the Serteya River the corresponding terrain could be found along the steep slopes of the valley at a distance of less than 2 km from the site. 'Swidden' farming was well suited to the natural renewal of forests. After the plots were abandoned, the area was populated by young birch and, later, by mixed forests dominated by deciduous trees.

Analysis of the palaeolandscape suggests that at the beginning of the Subboreal fertile soils along the margins of the lakes were used as fields for crops and cattle herding. These soils

developed as a result of lake shore swamping. The chemical compositions of sapropel and coastal sandy clay sediments also suggest the appearance of agricultural activity. An increase of Ti and Al is found in sapropel deposits at the beginning of the Subboreal. An increase in the concentration of Ti, Zr, Hf and Al is also evident at the site of Serteya X in the layers of a coastal part of the lake formed during the same time. This could be linked to soil erosion resulting from disturbance by agricultural activity near the settlement (Mazurkevich 2003; Arslanov *et al*. 2009: 113–15; Mazurkevich *et al*. 2009: 151–2). Finds of agricultural implements (hoes and ploughs) also provide evidence for the existence of agriculture (Fig. 13.9).

Material culture of the pile dwellings

The material culture of the pile dwellings that appeared in the first half of the 4th millennium cal BC exhibits discontinuity with that of the preceding culture at the end of the Early Neolithic. The oldest sites are dated on the basis of conventional radiocarbon measurements to 3700–3450 cal BC (4920±50 BP [LE-1006] – Naumovo, 4830±30 BP [Ta-242] – Usviaty IV, 4820±130 BP [LE-6280] – Dubokrai V, 4760±200 BP [LE-4112] – Serteya VIII, and 4650±60 BP [LE-5263] – Serteya X). All of them belong to Usviatian Culture. The following Zhizhitsian Culture has dates in the range 2550–2250 cal BC (3945±45 BP [LE-5383g], 3860±20 BP [LE-6202] – Serteya II). The final phase (North Belorussian Culture) of pile dwellings has dates around 2250–1950 cal BC (3650±70 BP [TA-634] – Serteya II; and 3700±70 BP [Ta-816] – Naumovo) (Figs 13.4–13.5). Pile dwellings existed until the beginning of the 2nd millennium cal BC. Each phase of the pile dwellings' history reflects both changes in culture and foreign influences that led to modification of the local culture.

Pottery (Fig. 13.5) from the Usviatian Culture is represented by vessels with flared rims, forms that include characteristics of a cylinder plus a cone, low-volume vessels with turned-in rims and biconical forms, and vessels of simple conical form with rounded or flat bottoms. Wall thickness varies from 6 mm to 10 mm. Organic material or shell was used as temper; the latter was predominantly used during the early Usviatian Culture. During the last phase sand appeared as ceramic temper. The pots were made by coils that were joined together using the 'S' technique. There are also traces of paddle and anvil, as well as polishing and comb-tool techniques. Decorations consisted of motifs made by impressions with straight-edged or denticulated tools; incisions and rounded-incisions are predominant, whereas comb-ornamentation is the third most frequently observed form of ornamentation. Also, there are decorative elements consisting of oval pits, lines, and cord impressions. Designs are arranged in zones and do not cover the entire vessel surface. Motifs consist of geometric figures, rows of impressions, and impressions placed at angles to one another. Additionally, there are triangle, rhombus and hexagon motifs, the last mentioned in the form of honeycombs with incisions, zigzags, nets of lines, and cord impressions. The decorative system was formed under the influence of the Funnel Beaker Culture, whereas the appearance of 'honeycombs' and impressions placed at angles to one another is the result of influence from the Globular Amphora Culture. Cord and line ornamentation reflects the successive influences of these two cultures. Comb ornamentation belongs to the local tradition, but the motifs used reflect foreign influences.

Tools were made of high-quality black and grey flint of non-local origin. Flint implements are represented by 'daggers', small knives, tanged darts and arrowheads, quadrangular scrapers, end-scrapers on blades, knives on flakes, and massive scrapers. Most tools were found outside the perimeter of the living platforms. This suggests that activities such as flint knapping and butchering were done on the spot (Poplevko 2007: 179, 186, figs 95–98). Flint daggers made from long blades and daggers with short tangs appear at the beginning and middle of the 3rd millennium cal BC, respectively. The period of their occurrence coincides with the chronology of similar types of artefacts from Central Europe (Schlichtherle 2005: fig. 30).

Influences from the south, from the basins of the High Dnepr (Dnepr–Donets Culture) and Oka (Rhomb–Pit Culture), led to transformation of the local culture and formation of the Zhizhitsian Culture. Pottery from Zhizhitsian Culture (Fig. 13.5) is represented by vessels made in the 'S' technique and also by slabs or coils. There are traces of polishing, smoothing, and use of a comb-tool. Sand, organic materials (including grass) and, more rarely, shell were used as temper. Pottery was fully decorated and

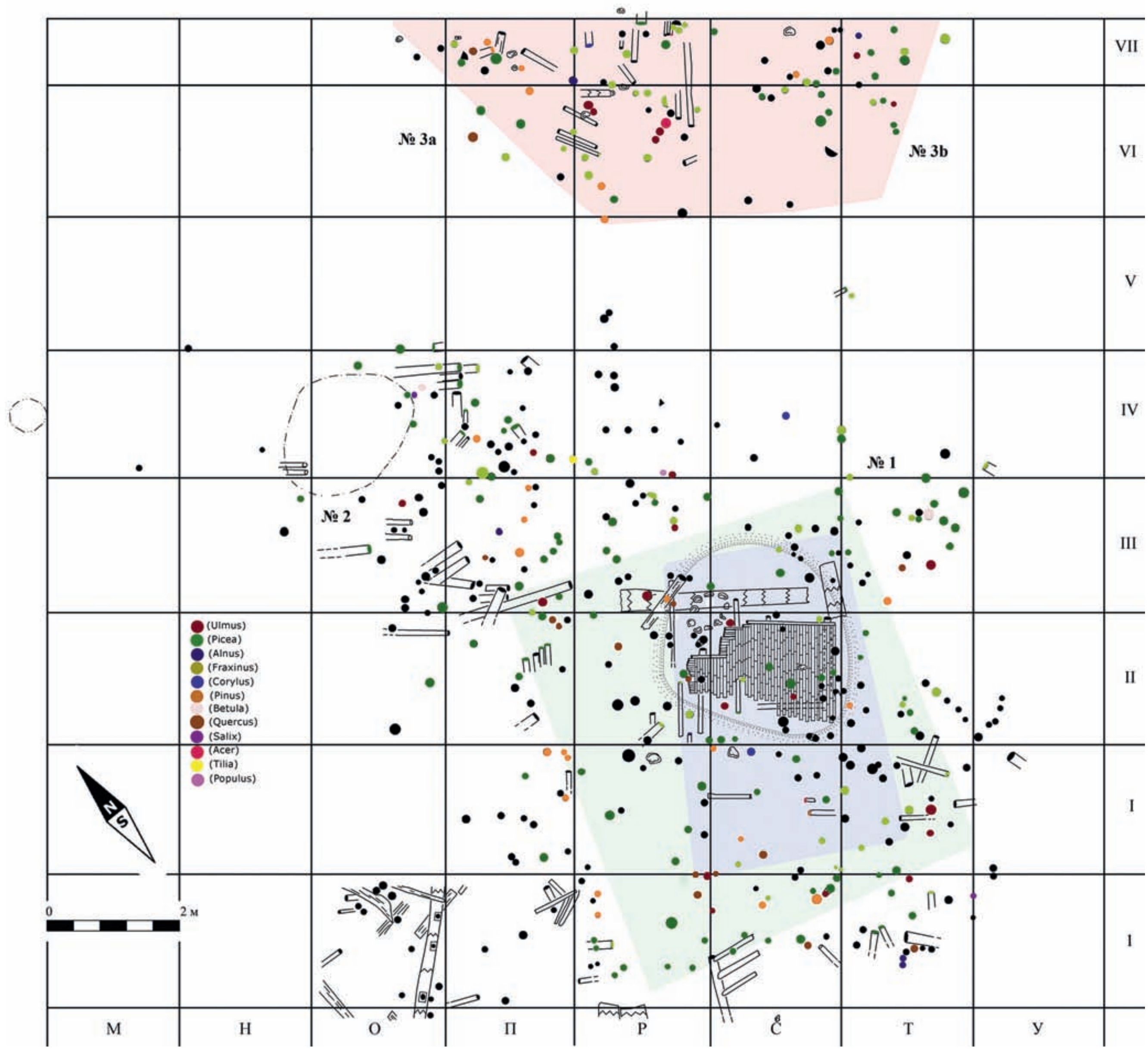

Figure 13.6: Plan of structural remains on the Serteya II site

the ornamental pattern was not determined by geography. Pottery was decorated with lines forming a net pattern, denticulate impressions, by cord made of bark, impressions of small knots, and elongated impressions of tools with flat edged or denticulated tools; it was organized in rows or staggered rows. There are also complex compositions made with different symbols and motifs. Vessels are of different forms compared to the Usviatian and Corded Ware cultures, and include small biconical, globular, and cylindrical vessel forms with flat or pointed bottoms. Cord impressions and cylindrical and globular vessel forms typical of the middle Dnepr Culture reflect influences from the Corded Ware Culture. There are also vessels with flat bottoms, trays as well as their imitations, and a ladle with a clay hand (see Mazurkevich 2006: fig. 92), but the most remarkable thing is the pintadera (Mazurkevich 2006). The pintadera (Fig. 13.7), which has a handle and a round surface, is 3.2 cm in diameter with three similar impressions along the edge of the surface. Analogues for this object can only be found in the archaeological cultures of the northern Balkans (see Makkay 1984: figs iii-7, xiii-6, and xviii–xxi). The appearance of a copper

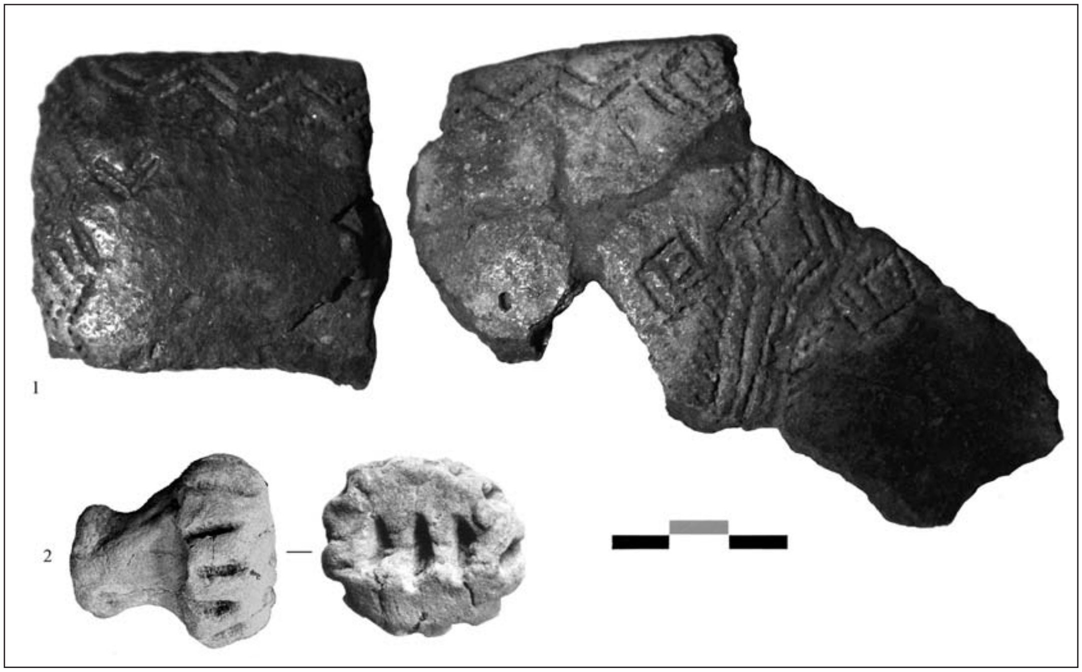

Figure 13.7: 1 pottery sherds with anthropomorphic motifs from Usviaty IV; 2 pintadera from Naumovo

awl found on the site of Usviaty IV is probably also connected to the influence of these foreign sources (Mazurkevich 2007: 236–40).

During the time of the Zhizhitsian Culture inhabitants of the pile dwellings used local boulder flint. Tools that had worn out were reused after reshaping. Flint tools are represented by rectangular scrapers, flake scrapers with an arched or straight working edge, leaf-shaped arrowheads, tanged arrowheads, and triangular arrowheads with a flat base or notch. Flint wedged axes appeared, as well as stone scaphoid and tanged axes that reflect Corded Ware Culture influence (Mikljaev and Semenov 1979: 13–15, figs 6 and 7).

Pottery of the North Belorussian Culture (Fig. 13.5) was made using the 'S' technique, sand and organic material was used as admixture, and the thickness of vessel walls varied from 5 mm to 6 mm. Unfortunately, owing to the conditions of preservation, the shape of the vessels cannot be reconstructed. Rims are straight with flat and mostly non-ornamented edges. Bases are round, though the occasional example is flat. The ornamentation system was similar to that of the preceding period but the amount of pottery with cord ornamentation increased twofold. Raw material changed; yellow-grey flint replaced black flint as the predominant material. The change of raw material source can be explained either by flooding of former flint sources or the disruption of cultural contacts with regions from where the raw materials previously used were obtained. Tools were made from flakes. Scrapers with a rectangular working edge, T-shaped scrapers, leaf-shaped arrowheads, tanged arrowheads, and arrowheads with a flat base or notch, are typical of the North Belorussian Culture. Types of cutting tools are analogous to those of the preceding period.

The following categories of objects were found at different sites. They occur sporadically, and so are presented together. Artefacts of bone and antler are represented by daggers made from elk ulnae, needle-shaped arrowheads, arrowheads with a biconical blade and flat haft element, uniserial harpoons with two holes in the haft element, borers with the metapodium reformed into a finial (one of which is ornamented), chisels, hoes of elk antler, bone spoons, denticulated stamps, and tools made of boar incisors. During the Late Neolithic the quantity of bone and antler tools decreased compared to the preceding period; however, the types are continuous.

The most representative collection of wooden artefacts comes from the sites of Usviaty IV and Serteya II (Figs 13.8 and 13.9). 'Mallets' are the most abundant category unique to the Middle Neolithic (Fig. 13.9). They are made of ash, oak and maple, and have an oval or rectangular head and handle. There is a hollow on each side of the head, resulting from use. Other categories

are represented in both the Middle and Late Neolithic: bent axe-handles made of oak and associated 'sleeves' of ash, hoes made from maple, a plough made from oak (Figs 13.9), and parts of oak spades. Several objects can be interpreted as paddles; they were always made of maple. One example measures 162 cm long; it has an elongated blade and the top of the shaft is carved in the form of two ducks' heads. Large dishes and ladles were made of ash, whereas small ladles, spoons, and spatulas were made of maple. The fragmentary remains of bows show that they were made of hazel, ash, and pine. Arrowheads of pine, and skis and sledge runners of ash, were all recovered. Nets were made of juniper and bilberry roots, and ropes were made from lime bast and rhizomes of juniper and bilberry. Small sacks made of birch bark filled with sand, stones, or fragments of pottery were used as sinkers for fishing and attached to birch bark twine. Mats were woven from fresh willow shoots, and birch and willow branches were used as plugs to patch holes in the bottoms of pots (Kolosova and Mazurkevich 1998: 52–4).

Two trapezoidal pendants of amber with longitudinal perforation seem to imitate teeth. They come from the site of Serteya II (Construction no. 1) and belong to the Zhizhitsian Culture, and date to the middle of the 3rd millennium cal BC (Fig. 13.8, 3). Another group of amber pendants was found at Naumovo (Fig. 13.8, 2) and Usviaty IV (Mikljaev and Semenov 1979). This group comprises oval pendants with transverse perforation, trapezoidal pendants with longitudinal perforation, and cylindrical pendants with unusual T-form perforation. These finds date to the second half of the 3rd millennium cal BC and belong to the North Belorussian Culture. Chemical analysis has shown that Baltic amber was used as raw material (Shedrinsky *et al*. 2004: 79–80; see Mazurkevich 2006: figs 82–86). The trapezoidal amber pendants are unlike the amber ornaments of the Globular Amphora Culture, or contemporaneous materials from the eastern Baltic (Czebreszuk 2003; Loze 2003a) since, in contrast to the last mentioned, they imitate animal teeth. The oval and cylindrical amber ornaments have some parallels with examples from the Corded Ware Culture and contemporaneous sites in Latvia and Estonia (Loze 2003a). The main differences between the local pendants and those of other regions are in the method of fabrication, the arrangement of the perforation for suspension, and the shape of the cross-section. The original fabrication technique, the shapes of the amber ornaments, and the discovery of raw amber on the site of Serteya X suggest that the raw material was transported from the eastern Baltic to the Upper Dvina region, and that the ornaments were made locally. Local inhabitants could compensate for the lack of raw amber in the area by active use of similar, available materials – resin resembled amber (evidenced from finds from a raw material field cut through by the Western Dvina River – Shedrinsky *et al*. 2004: 75).

Certain categories of 'art objects' may have

Figure 13.8: 1 wooden ladle with bear's head handle (length 28 cm) from Usviaty IV; 2 amber pendants (length 1.5 and 5.6 cm) from Naumovo; 3 amber pendants (length 1.9 and 1.7 cm) from Serteya II (construction no. 1)

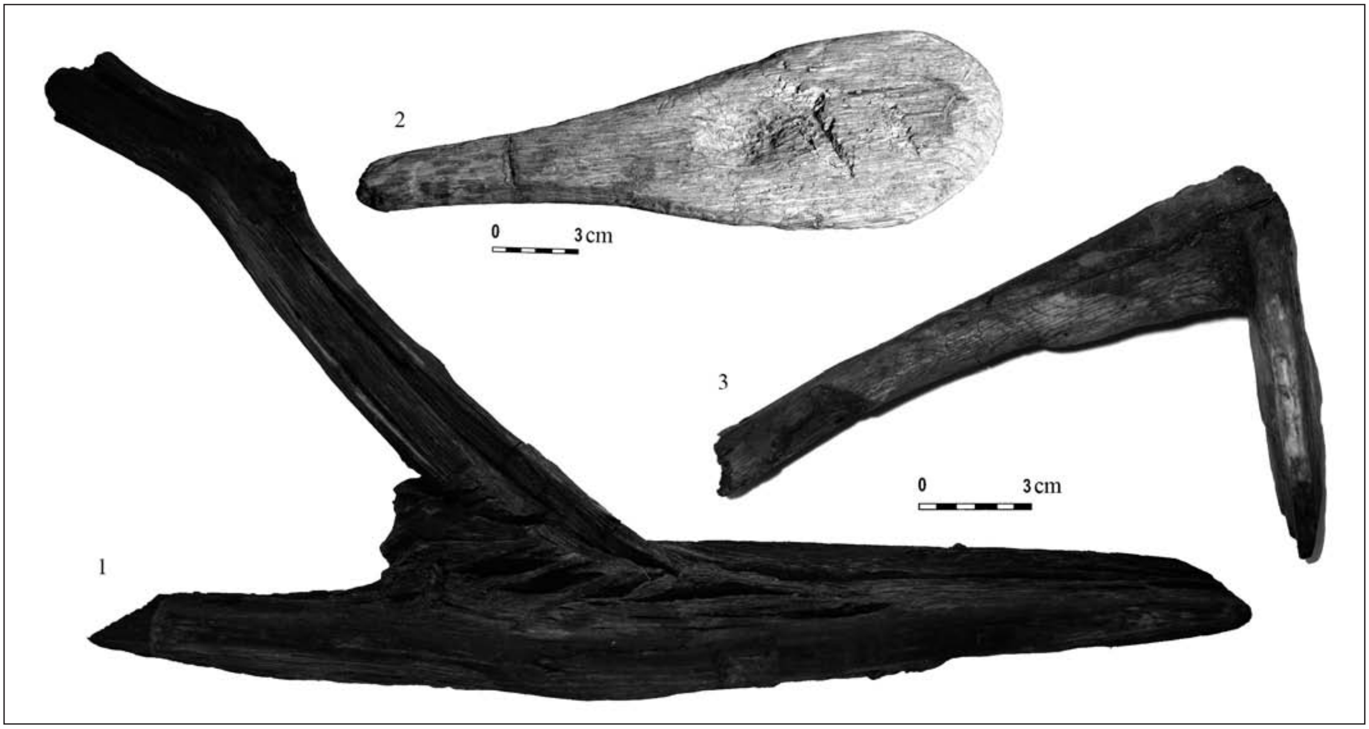

Figure 13.9: 1 plough from Dubokrai I; 2 wooden 'mallet' from Usviaty IV; 3 wooden hoe from Usviaty IV

been associated with the ritual activities of the inhabitants of the pile dwellings, interpreted here as a possible 'ancestor cult' – they comprise clay pots with anthropomorphic figures or signs (Fig. 13.7), an anthropomorphic spatula/spoon with undulating edges, sculptural images of humans and animals (Fig. 13.10), a wooden ladle with the image of a bear filled with burnt bone (Fig. 13.8), which was found near the spoon, a human mask, and a zoomorphic pendant (Mazurkevich 2006: 28, figs 26–29, 42 and 44–46). Functional and protective qualities of specific animals or ancestors may have been transferred onto the object (i.e. a paddle with a carving of ducks' heads at the top of the shaft) or onto the individual (i.e. a necklace of animal teeth, or imitations made of bone and amber – see Mazurkevich 2006: figs 85–86). However, finds of these types of artefacts are rare. The sculptural images of humans and animals have distinctive features – the accurate representation enabled us to identify the animals portrayed. Moreover, the absence of eyes, elaborated eye-sockets, cheek-bones, ears, chin, mouth, and lips suggest an emotion or behavioural characteristic in the perception of the image. One example is the mimicry of a human face from cultural layers in the site of Usviaty IV (Fig. 13.10); this face may be associated with such emotions as tension and expectation, or with shouting. Another from Osovec II may show severity or depression, and the mask from Djazdica possibly shows severity or cruelty. The physical strength of male figures was represented by shoulder girdle muscles.

Almost all art objects from the Neolithic may be classified into two groups – sighted (Fig. 13.10, 1) and eyeless (Figs 13.8, 1 and 13.10, 3) figures. Most of the eyeless animals and humans come from burials or other ritual places. This fact allows us to suppose a connection between eyeless images and the semantic field of another world – the world of ancestors and the world of the dead. Usually, sighted figures are represented by animals, including birds, the eyes of which could have been inlaid, as suggested by the character of the eye sockets. Ochre may have been used as the material for encrustation; ochre was found in the eye sockets of some pendants that have the form of birds' heads. These figures may concern another semantic field – that of resurgent or living creatures that played a guarding role.

Large vessels with anthropomorphic images are very important and may be evidence of feasting. Anthropomorphic graphical signs decorating the pots of the Usviatian Culture (at Usviaty IV – Fig. 13.7) may represent coded signs of a genealogical tree and/or the social structure of the inhabitants of the pile dwellings, by comparison with ethnographic examples (Carpenter 1986). At the site of Usviaty IV traces

Figure 13.10: 1 male figure (length 9.5 cm) from Usviaty IV; 2 zoomorphic pendant (length 5 cm) from Serteya II (construction no. 3); 3 bone 'blade' with raven's head (length 16 cm) from Usviaty IV

of funeral feasting were found; the animal eaten during the feast was specifically collected in the ladle with the head of an eyeless bear and taken out to the perimeter of the living space – a spoon was placed nearby. The question must then be considered, for whom was it necessary to have such a feast, and when was it held? We suggest this action was undertaken for a chief who had taken under his control different aspects of social life, including ritual and economic activities.

The form of the pile constructions changed through time. Part of an oval construction was found in an early horizon of Usviaty IV. Later rectangular constructions (measuring 14 × 6 m) appeared, which became typical for the following chronological horizon of Usviaty IV and the Naumovo site. Pile dwellings of the Zhizhitsian and North Belorussian cultures consisted of one or several rectangular constructions (Fig. 13.6) measuring 5.5 × 4.5 m. Rectangular platforms formed the base of the pile dwellings, which were elevated 50–70 cm above the surface of the shore. Logs 9–12 cm in diameter were attached to piles with the aid of ropes and supported by 'horned' piles. Poles 5–8 cm in diameter were densely laid transversely on top of the logs; pine slabs *c*. 6 cm thick (without bark) were placed above them. A layer of moss would have been placed on top of the pine and a layer of coarse white sand, some 8 cm thick, was spread across the moss layer. The circular hearth placed on the sand was built with large stones. Piles 14–22 cm in diameter were placed around the periphery. They served as a framework for walls that may have been made of branches. Clay fragments found here can be interpreted as daub fragments. The presence of the row of piles in the middle of the construction may indicate the existence of a pitched roof. The platforms were encircled by garbage dumps located along one of the short walls and along adjacent parts of the long walls; it is likely there was a doorway in the short wall. Pile dwellings were situated along the shore and were connected by passages. All the structures faced the central part of the site, which was filled with garbage dumps (Mikljaev 1971; Mazurkevich 1998). The distribution of boars' faeces suggests that boars were kept for some time on the site, apparently not inside the constructions but next to them in a pen.

Discussion and conclusions

There are very important questions concerning the reasons for the construction and the general phenomenon of pile dwellings. Perhaps the most pertinent information stems from the analysis of the landscape in which these prehistoric people chose to live. One reason suggested is the desire of the Neolithic builders to free up land that was suitable for agriculture and cattle herding, a theory that has been suggested for Central European pile dwellings (Vogt 1977). Furthermore, ancient inhabitants had to take into account many factors before erecting these dwellings, which functioned as year-round settlements. By the time pile dwellings appeared, the water level had fallen significantly and mires had appeared. Shores had become overgrown with alder that made it difficult to approach the lake. The lakes became eutrophic and open water would have been some 100–250 m from

shore. Hence ancient people tried to settle near the water – small eutrophic stagnant lakes surrounded by mires. Dwellings would need to have been constructed over the mires along the shores, rather than in the lake, due to the risk of freezing over.

Pollen and diatom analyses suggest that the Atlantic and Subboreal periods were characterized by frequent changes of water level (Arslanov *et al*. 2009: 118–20). The erection of pile dwellings made the settlement immune to seasonal or gradual variations in water level caused by climatic changes. The geology of the region meant that the area suitable for settlement would have been either situated far from the lake or flooded periodically, becoming almost impassable due to the loamy soil. It may have also been easier to protect against mosquitoes during the period of maximum extension of broad-leaved species because of the openness of the locality.

In contrast to the rather mobile population of the Early Neolithic, whose subsistence economy was dependent on seasonal changes, the situation changed substantially in the Middle Neolithic. The combination of different types of landscape with rich natural resources made a hunter-gatherer economy effective and sustainable based in sedentary year-round villages. Therefore, judging from the pollen record, the establishment of an agricultural economy was substantially delayed. According to pollen evidence agriculture appeared in several impermanent stages. It may have represented a prestigious 'package' that included not only cultivation and cattle herding, but also amber ornaments and weapons. Changes in climate, degradation of broad-leaved forests, a fall of the water level, the formation of bogs, and the reduction of lake productivity in the Subboreal may have resulted in the reduction of wild food sources, as well as restricting access to drinkable water in the region. These circumstances are likely to have contributed to the change of economic strategy – settlements becoming inhabited year round, and as the population became more settled, starting to store more food and water. At that time (the Atlantic/Subboreal transition) high-capacity vessels appear (Fig. 13.5) and the population increased. The subsistence economy and distribution system changed, which inevitably resulted in a change of social structure (Mazurkevich 2003).

From the 4th millennium cal BC western regions were under the constant influence of middle European cultures with productive economies, and these contacts can be traced through material culture. Ancient inhabitants began to develop new economic strategies – agriculture and animal husbandry. The new and complex economy would have affected social structure and culture in general. This likely explains the predominance of anthropomorphic sculpture in the western part of the forest zone of Eastern Europe (Loze 2003b), while contemporaneous practices in the east included the widespread cult of the elk, bear, and zooanthropomorphic figures. Many, ethnographically known, traditional societies (e.g. Sahlins 1974) offer parallels for the material culture of the Neolithic inhabitants of northwestern Russia. Thus big changes in social structure, such as the appearance of chiefdoms, can be observed based on the interpretation of material from the Middle Neolithic Usviatian Culture.

The lacustrine pile dwellings, which appeared in the first half of the 4th millennium cal BC, were unique sites among the Middle Neolithic cultures of the forest zone of northeastern Europe. To the east and north of the Dnepr–Dvina region were sites with Pit–Comb pottery, to the south were sites with Rhomb–Pit pottery, and to the west the Late Narva Culture occurs. Judging from published data, pile dwellings may also exist on the northeastern Baltic shores of Sarnate and Shvjantoji. The territory of pile dwelling expansion includes the basin of the upper (Serteya II, Usviaty IV, and Dubokrai V) and middle Western Dvina River (sites of the Krivinsky peat bog in the territory of Belarus). They are situated in specific landscape conditions that allowed Miklyaev (1995) to predict the existence of a cultural-historical corridor connected by a chain of lakes where pile dwellings were situated. This theory was later confirmed by the discovery of pile dwellings in this region, which is now the territory of Belarus and Poland.

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14

A Late Neolithic Fishing Fence in Lake Arendsee, Sachsen-Anhalt, Germany

Rosemarie Leineweber, Harald Lübke, Monika Hellmund, Hans-Jürgen Döhle and Stefanie Klooß

In 2003 a Neolithic wooden fishing fence structure was discovered in the Arendsee, a lake in the north of Sachsen-Anhalt (Germany). Situated at the northern border of the lake, it was found in a horizontal position covered by marl sediments. So far the estimated length is more than 150 m. This discovery and the methods of diving in Lake Arendsee are described. Owing to natural land subsidence, triggered by subrosion, the fishing fence lies at a depth of 9–11 m, which is deeper than when it was in use. Radiocarbon analyses date the wooden artefacts to the 3rd millennium cal BC. Scientific research in 2004, 2005–6, and 2007 included excavations at several sites and the collection of sediments for pollen analysis. The results of the pollen analysis are supported by wood analyses of the Neolithic fence. The fence was made of thin wooden sticks of Corylus, *bound with rope, one sample of which was identified as the phloem of* Acer campestre. *The pollen spectra of the 'on-site' sediments of the Neolithic fence can be dated to the Subboreal, i.e. the period after the* Ulmus *decline. Remains of four fish species, pike, bream, perch, and pikeperch, were identified in the surrounding sediments. In comparison to similar fishing fences from Northern Europe, the fishing fence of Lake Arendsee demonstrates a practice that was certainly often used, although the structure is of a type that is rarely documented for the Late Neolithic. The Arendsee fishing fence is the oldest such find from a lake in Germany, and the first evidence for the coppicing of hazel bushes in the Arendsee area during that period.*

Keywords: fishing fence, Late Neolithic, underwater archaeology, hazel, fish remains

Topography and lake history

Lake Arendsee is situated in the Altmark region of northern Sachsen-Anhalt, close to Wendland in the state of Lower Saxony (Fig. 14.1). The lake presently covers an area of 5 km^2 and has a maximum extent from west to east of 3.5 km and *c*. 2 km from north to south. With a maximum depth of a little over 50 m and an average depth of 29 m, it is one of Germany's deepest inland lakes. The present lake level is 23 m above sea level (Seelig *et al*. 2000: 75). The shore area in the south and west is steep, but in the north and east it is reasonably shallow. The town of Arendsee was founded on the southeast shore of the lake in the Middle Ages.

The origins of Lake Arendsee have not yet been fully investigated. By the Late Glacial period, *c*. 12,700 cal BC, a smaller lake existed, corresponding to the western part of the present lake (Leineweber *et al.* 2009). During the Holocene, the lake increased in size owing to subsidence of the lake bottom triggered

Figure 14.1: The location of Lake Arendsee, northern Germany (Map: N. Seeländer; © LDA)

by *subrosion* (dissolution or leaching of water soluble rocks in the sub-surface). Penetrating groundwater dissolved areas of the anhydrite cap rock above the subjacent salt dome. Several times during the Late Pleistocene and Holocene, these processes caused collapses of the remaining parts of the roof so that saline deep water seeped through into the lake basin (Thormeier 1993: 11). As a result of these processes, the size and depth of Lake Arendsee, as well as the location of the collapses, changed several times during the Holocene. So-called 'lake collapses' were described in AD 822 and AD 1685. According to the observations of the Arendsee diving club (TCA), small base failures of the lake bed still occur (Scharf *et al.* 2009). Besides the sudden lake collapses, the lake bed has sunk continuously over a longer period owing to subrosion in the underlying geology (Hartmann and Schönberg 2003, 2009).

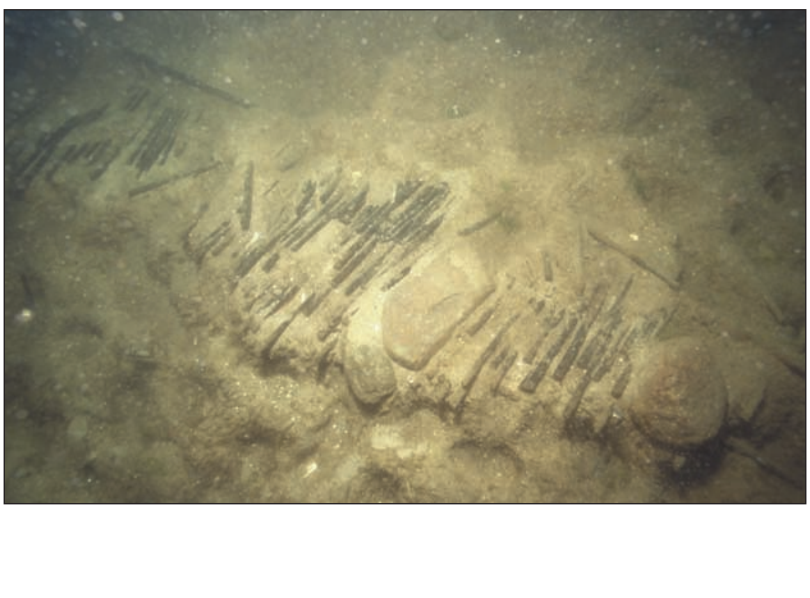

Figure 14.2: Discovery of the wooden Late Neolithic fishing fence. Outside the fishing season the fence was fixed with larger stones to the bottom of the lake (Photo: H. Lübke; © LDA)

History of underwater site discovery

The Neolithic fishing fence of the Arendsee was discovered accidentally by sport divers in 2003 (Leineweber and Lübke 2006, 2009a). The first archaeological object detected was a wooden log boat from the Middle Ages that was found at the northern border of the lake (Leineweber and Lübke 2009b). A more intensive search of the adjacent shore area revealed some wooden sticks at a depth of 9–11 m in a steep slope of the lake bottom where the lake marl was eroded (Fig. 14.2). A review of these findings by archaeological scientific divers of the State Authority for Culture and Protection of Monuments Mecklenburg-Vorpommern confirmed these to be the remains of a fishing fence. The underwater archaeologists took samples of the wooden artefacts, which were dated by AMS ^{14}C to the Late Neolithic (Table 14.1: Erl-8019). Further underwater surveys were undertaken by the sport divers who detected another part of a Late Neolithic fishing fence in the northwestern part of the Arendsee. Recently, parts of these archaeological features were excavated, although the greater part of the lake has not yet been surveyed.

Methodology

Since the discovery of the spectacular Neolithic artefacts, an interdisciplinary team with expertise in archaeology, geology, limnology, archaeobotany, and archaeozoology was established to investigate the archaeological findings as well as the environment of the Late Neolithic fishing fence. The tasks included the:

- investigation of the Holocene lake development;
- investigation of the history of sedimentation and erosion;
- investigation of the lake bed by geophysical and remote-sensing surveys;
- identification, documentation and excavation of the archaeological structures;
- identification of plant residues, including wood samples, macro remains and pollen;
- identification of fish remains;
- conservation of the archaeological remains;
- dating of the sediment layers through pollen analysis;
- AMS ^{14}C dating of selected artefacts.

Sample description	Origin	Sample material	Lab. No.	^{14}C Age (BP)	Calendar Age (cal BC/AD)	Calendar Age (cal BP [0=AD1950])	$\delta^{13}C$
Fishing fence	NE sector						
FZ-NE-01	Individual sample	Rod	Erl-8019	4078±50	2680±130 BC	4630±130	-31.4
G827-17	Trench 1, Layer 1	Rod	KIA-29668	3825±25	2270±50 BC	4230±50	-29.6
G827-20	Trench 1, Layer 1	Stake	KIA-29670	3862±25	2360±60 BC	4310±70	-28.8
G827-19	Trench 1, Layer 2	Stake	KIA-29669	3725±26	2120±60 BC	4070±60	-31.5
G827-14	Trench 1, Layer 2	Stake	KIA-29665	3883±26	2380±60 BC	4330±60	-24.9
G827-15	Trench 1, Layer 3	Stake	KIA-29666	4008±26	2530±40 BC	4480±40	-28.3
G827-16	Trench 1, Layer 3	Rod	KIA-29667	4019±25	2530±40 BC	4480±40	-28.3
G827-06	Trench 2	Rod	KIA-29663	3845±24	2320±70 BC	4270±70	-26,7
G827-09	Trench 2	Stake	KIA-29664	3831±20	2270±40 BC	4230±50	-32.3
Fishing fence	NW sector						
FZ-NW-01	Individ. sample 8 m water depth	Rod	KIA-31805	3877±26	2380±60 BC	4330±60	-29.1
FZ-NW-02	Individ. sample 8 m water depth	Rod	KIA-31806	3890±24	2390±50 BC	4340±60	-29.8
FZ-NW-03	Individ. sample 7 m water depth	Rod	KIA-31807	3842±25	2310±70 BC	4270±70	-29.7
Surface finds	NE sector						
5/07-1	Lake floor, 5 m water depth	Post 1	KIA-33273	391±27	1510±70 AD	440±70	-25.9
5/07-2	Lake floor, 5 m water depth	Post 2	KIA-33274	77±26	1800±90 AD	150±90	-28.0
5/07-3	Lake floor, 5 m water depth	Post 3	KIA-33275	347±26	1540±60 AD	410±60	-27.3
5/07-4	Lake floor, 8 m water depth	Fish trap	KIA-33276	1186±27	820±40 AD	1130±40	-27.8
5/07-5	Lake floor, 7 m water depth	Post 4	KIA-33277	190±31	1780±110 AD	170±110	-25.8
Lake marl bank	NE sector						
5/07-40	Trench 6	Stick	KIA-35500	8957±39	8130±110 BC	10080±110	-25.8

Table 14.1: AMS ^{14}C dates (one-sigma calibrated age ranges BC/AD) for all wooden fragments sampled in Lake Arendsee, 2005–7. The calibrations were performed with the program CalPal, ver. 2007 (Weninger et al. *2009) and the calibration curve IntCal04 (Reimer* et al. *2004).*

The fieldwork was conducted over two seasons in the winter of 2005/2006 and the spring of 2007 by a five-member research group of divers and a supporting land-based team. Additional remote-sensing surveys of the northeastern shallow water area of the lake took place in the summer of 2006. The excavations had to be carried out during the winter because of the restricted visibility in the deeper water due to algal growth throughout the warmer months of the year. The scientific divers applied the German rules for scientific diving (GUV-R 2112 – *Regeln für den Einsatz von Forschungstauchern*), with a dive supervisor and a standby diver for emergencies, and compressed air supplied through SCUBA equipment with full-face masks. Contact with divers was kept via wireless voice communication transmitter and a total of three workboats were used (Fig. 14.3). An 8.5 m long rigid-hull cabin boat was permanently fixed during the day directly above the excavation, serving as a working platform for the divers and to take the diving equipment as well as the lightweight technical excavation and documentation equipment. An open rigid-hull workboat 5.50 m in length was necessary to operate the pump for the underwater dredge and the associated heavy excavation equipment.

Figure 14.3: The three workboats used by the scientific dive team during the excavation campaign on the Arendsee (Photo: A. Hörentrup; © LDA)

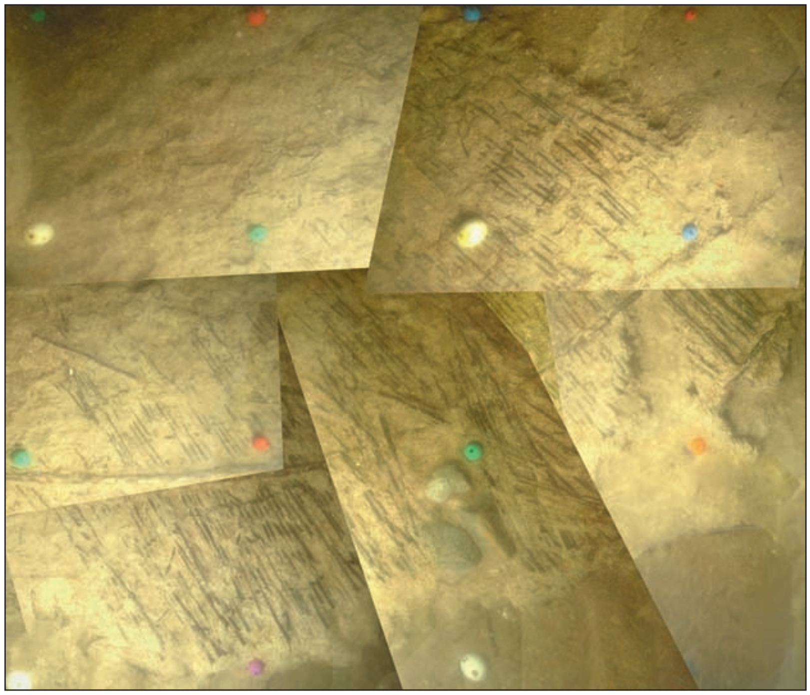

Figure 14.4: Arendsee fishing fence, Trench 1. Detail from the rectified photo mosaic of the Late Neolithic fishing fence. Each photo used has 4 to 5 plastic balls as identification points (Rectification and photo mosaic: R. Scholz, Vierkirchen, based on photos by H. Lübke; © LDA)

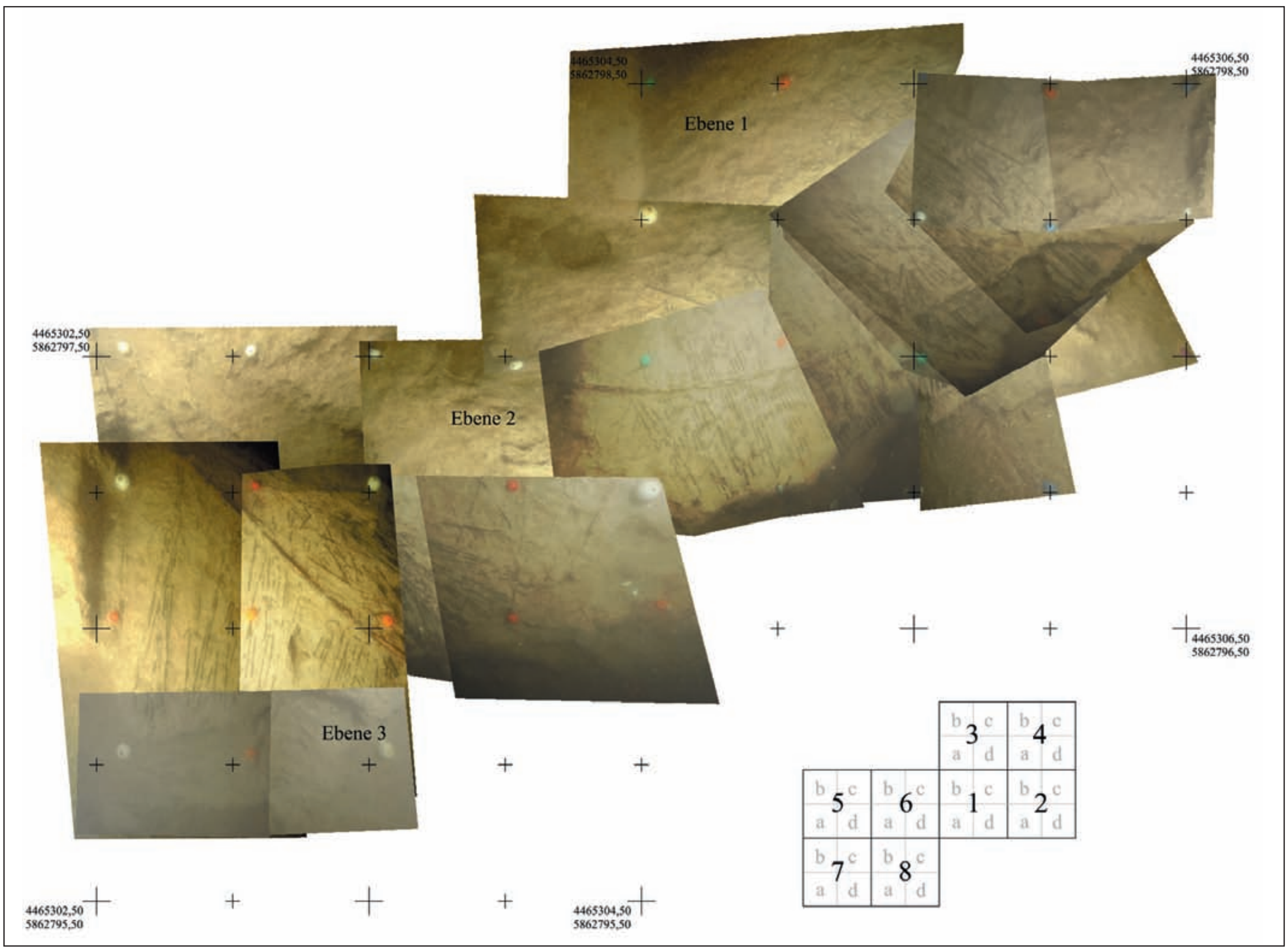

Figure 14.5: Arendsee fishing fence, Trench 1. Rectified photo mosaic of the fishing fence structures in Trench 1, layers 1 and 2 (Rectification and photo mosaic: R. Scholz, Vierkirchen, based on photos by H. Lübke; © LDA)

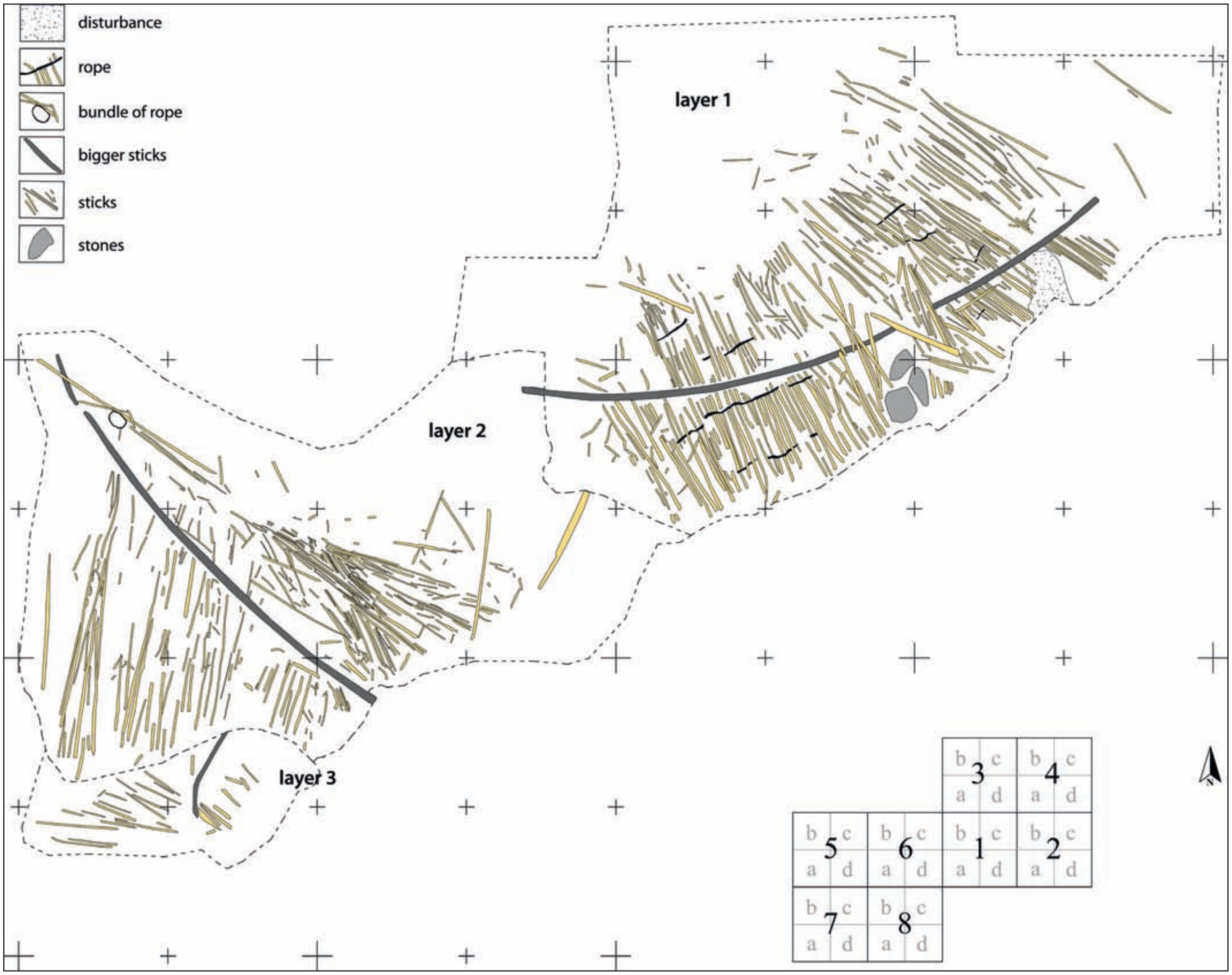

Figure 14.6: Arendsee fishing fence, Trench 1. Digitized illustration of the fishing fence structures in Trench 1, layers 1 and 2 (Digital drawing: R. Scholz, Vierkirchen; B. Parsche; © LDA)

Owing to the operating noise of the pump, the smaller boat was anchored some distance from the cabin boat. For the necessary liaison services between the boats and dock, and to provide additional protection for the divers, a 6.5 m rigid-hull inflatable boat (with outboard motor) was also available.

The excavation areas were marked with buoys and, normally, two divers worked simultaneously with handheld dredges to excavate the archaeological structure on the lake bed. A third diver was sometimes used for photographic/video documentation or to explore the surrounding area. Depending on the respective tasks, each scientific diver worked between 30 and 90 minutes underwater because of the water depth of about 9–11 m and the low water temperature (<4°C).

During the first excavation campaign in the winter of 2005/2006, two excavation areas measuring 8 m^2 were each established in order to study the construction of the fishing fence in detail and to allow sampling of the selected areas. In spite of good visibility in the lower waters above the lake bottom, absolute darkness prevailed because of the algal density in the upper water layers above 6–7 m water depth. Therefore, artificial light (diving lamps) was required and after excavating the archaeological layer with a water dredge, a special photo-mosaic technique had to be applied for documentation of the fishing fence remains.

The uncovered layers were marked in the exposed areas of the excavations; at 1 m grid intersections large white plastic balls were placed, while all 0.25 m grid intersections were marked with smaller coloured balls. Subsequently, vertically above the trench a floating diver took

numerous overlapping images of the excavated layers with a digital camera and twin strobe flash units. Because of the absolute darkness, the autofocus of the camera needed a pilot light from one of the two strobes, which was shone on the desired target where the camera should focus. Recognition of the excavation by the diver was only possible with the use of this pilot light, which was also used to help maintain a constant distance to the lake bottom for photography. A general overview of the entire excavation area was not possible because of the darkness; therefore, photographing each section was largely blind, and the highest possible number of photos per layer was sought.

Following each dive, the digital images were uploaded to a PC and sorted by grid squares; only those images containing at least four plastic balls were selected (Fig. 14.4). The next step was to standardize (the size and scale of) the individual photos, which were then combined into a photo mosaic (Fig. 14.5). Based on these photo mosaics, one could recognize the overall findings in the survey and thus the digital illustration of the fishing fence was carried out (Fig. 14.6).

On completion of the digital photo documentation from the exposed Trench 1 of the 2005/2006 excavation campaign, fishing fence elements were recovered in 1 × 1 m as well as 2 × 1 m metal boxes with the help of the technical staff of the THW (Federal Agency for Technical Relief) (Fig. 14.7). The secured fence elements were then documented again on land, sampled, and sent for conservation in the central workshops of the Archaeological State Museum of Schleswig-Holstein in Schleswig. The artefacts were conserved by polyethylene glycol (PEG) and freeze-drying.

Parallel to the documentation of the structures uncovered in Trench 1, work continued in a second trench, and the exploration of the environment began. This work had to be terminated prematurely, however, because the lake froze over due to an intense cold spell in January 2006 when diving was no longer possible.

In 2007 a larger area was investigated. The main task of this campaign was the verification of the results from the remote-sensing surveys undertaken in the summer of 2006. For this reason, six adjacent trenches, each measuring 2 m², positioned along a 400 m long alignment from the fishing fence to the northern lake shore, were excavated. In four cases, as a precaution, they were expanded to 4 m² in order to reach more than a one-metre depth. Furthermore, additional drillings were carried out with a Pürckhauer auger to reconstruct the sedimentation along the alignment.

In addition, from three of the areas pollen samples were collected – sediment monoliths were taken in metal sample tins (measuring 60 × 15 × 15 cm) in Trenches 3 and 6, and in separate plastic tubes (10 cm long and 5 cm in diameter) at a sampling distance of 10 cm in Trench 5. Furthermore, at other sites in a 5–7 m water depth, salvaged wooden piles were measured and sampled to determine their age by AMS dating or dendrochronology.

Results and interpretation

Geomorphology of Lake Arendsee and pollen analyses

The excavations conducted in the spring of 2007 provided important new insights into the geomorphology and the development of the northern shore of Lake Arendsee (Fig. 14.8). In the shallow waters at Trench 2, core sampling was carried out. In this area no lake marl was found under the 10 cm thick, loose, sandy sediment on the bed of the lake. Instead, a layer of fine sand interspersed with fine roots followed immediately, but no lake marl was present. Whether this fine sand is of aeolian origin could be determined by further pedological investigation.

Toward the open lake at a depth of >6 m, in Trenches 4 and 5, the base of the lake marl was not reached because there the marl was >4 m thick. In the sections different coloured strata reflecting varying organic content were discernible within the marl. In Trench 5, which was furthest from the shore, sediment samples were taken at intervals of 10 cm for palynological analysis.

In a water depth of 3–6 m, cores 1, 3, and 6 reached the mineral layer under the lake marl.

Figure 14.7: Recovery of a part of the Late Neolithic fishing fence in a metal box using special technical support (THW) (Photo: U. Brinker; © LDA)

In the profiles of trenches 3 and 6 the remains of a terrestrial palaeosol could be identified. Therefore, sediment monoliths were taken from these two profiles with sampling tins for sedimentological and palynological study.

In the northern part of Lake Arendsee, sediments from several locations were sampled for palynological analysis. Profile FZ includes three layers of the fishing fence, the adjacent core ARS 4, as well as material from excavated sections 3, 5 and 6, mentioned previously. In addition, there are four 10 cm profiles from the four sampling tins with parts of the middle and the lower fishing fence and their surrounding sediments (see below).

Although the absolute levels of the lake bed in sections 3, 5 and 6 differ by only 1–2 m at the present depth of 5–7 m, the pollen spectra differed noticeably from one another and were of differing biostratigraphical ages (Hellmund 2009). The pollen analyses revealed the heterogeneous age of the topmost sediments at the different sites. The oldest was at Site 3 in the north, in the neighbourhood of the present lake shore. Sonar analysis revealed the relatively high density of the subsoil in this area and may indicate the existence of a lake shoreline during the Neolithic at Site 3. However, pollen analyses revealed that there was already lacustrine sedimentation here in Preboreal and Boreal times. Later sediments were not preserved there. In Trench 6, the upper part of the pollen diagram is comparable with the pollen spectra from the fishing fence area. In the lower part of the profile, a wooden artefact was excavated at the base of the lake marl above the palaeosol, and was ^{14}C dated to 8130±110 cal BC (KIA-35500; Table 14.1). This date and results of pollen analysis show that lacustrine sedimentation had already begun in the northern part of Lake Arendsee by the Early Holocene, although previous studies (e.g. Röhrig and Scharf 2002; see also Leineweber *et al.* 2009) assumed that the Arendsee developed from the Subboreal period onwards. Therefore, the underlying palaeosol must be much older than the Late Neolithic fishing fences (see below).

Given the data now available, it is unlikely that a Neolithic settlement or the contemporaneous

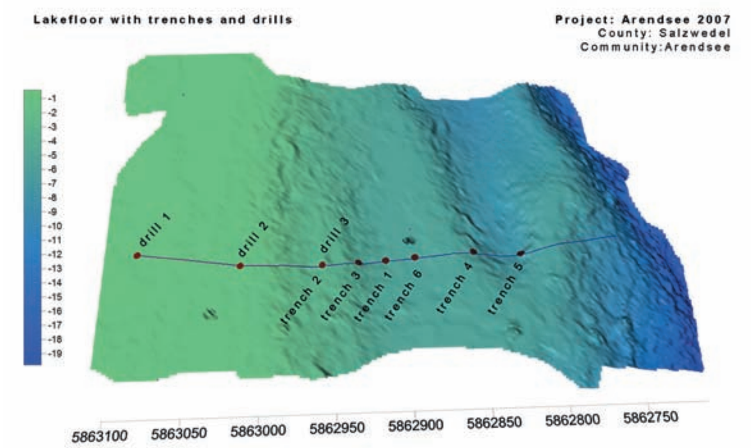

Figure 14.8: Three-dimensional representation of the lake bed in the northeastern sector of Lake Arendsee. The activities of the field campaign in March 2007 have been marked: along a north–south oriented measurement axis, Trenches 1–6 were excavated and sediment drillings 1–3 were carried out (Digital drawing: R. Scholz, Vierkirchen, based on sonar measurements by K. Storch, SOSO Sonder-Sonar, Jena; © LDA)

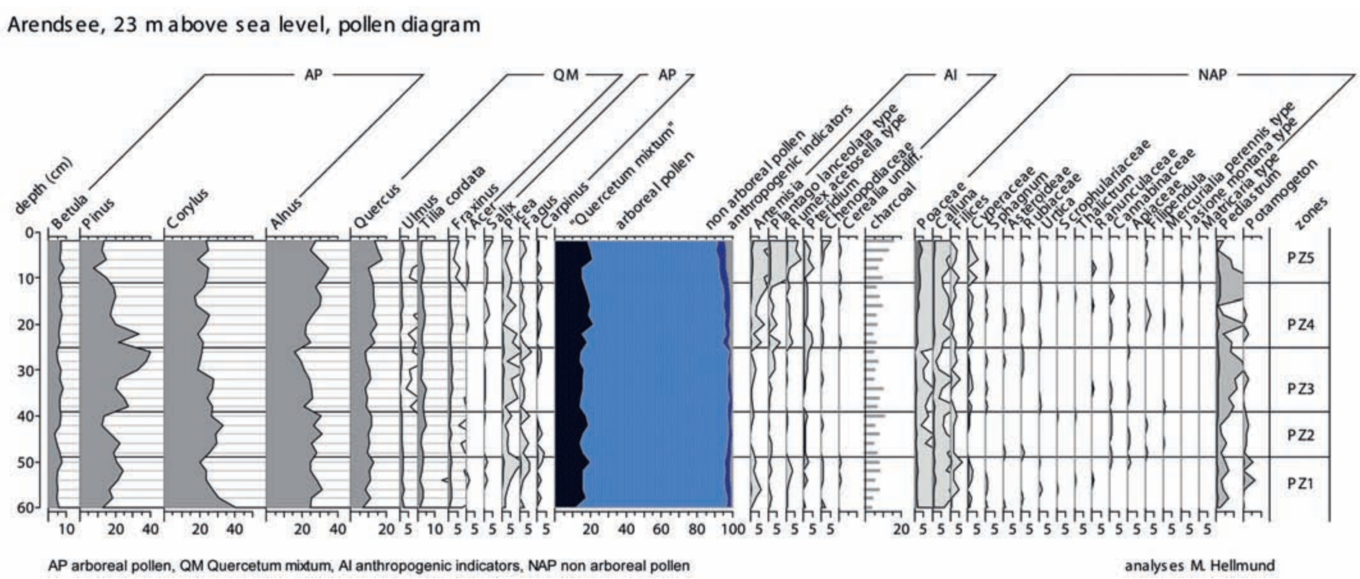

Figure 14.9: Pollen diagram of the sediments of the Late Neolithic fishing fence. The uppermost pollen zone is characterized by a higher frequency of anthropogenic indicators. Pollen sum per sample >1000 pollen and spores from land plant species. Second curve of each pollen type 10x (Drawing: M. Hellmund, using TGView v2.02 by Eric Grimm; © LDA)

lake shore will be found in this area. It is obvious that the Neolithic fishing fence was made and used by humans who settled the surroundings of the former lake, though their settlements have yet to be located. The pollen sequence at Site 5 was much younger than the spectra from Trenches 3 and 6, and was dated to the youngest Subboreal and the Subatlantic. Trenches 3 and 6 did not contain sediments this young.

The pollen spectra analyzed were closely connected with the three layers of the fishing fence. The upper part of the fishing fence location (Fig. 14.9) shows a relatively high frequency of anthropogenic indicators in its pollen spectra, which includes plantain (*Plantago lanceolata*), wild grass type (Poaceae), and fragments of charcoal. In the oldest (bottom) part of the fishing fence, the frequency of anthropogenic indicators was comparatively low. Therefore, the pollen spectra from the Late Neolithic period of Lake Arendsee are characteristic and can be correlated biostratigraphically with neighbouring pollen diagrams (Christiansen 2009). Supplementary pollen analyses of the neighbouring locality ARS 4 were carried out. This pollen diagram covers the period with the Neolithic Elm Decline, which is not represented in the diagram from the fishing fence location. The frequency of anthropogenic indicators from the Late Neolithic sample is strikingly high. Additionally, isolated earlier evidence of *Plantago lanceolata* in the time span since the Neolithic Elm Decline testifies to the presence of humans in the region during the Middle Neolithic Funnelbeaker period (Hellmund 2009).

Figure 14.10 (top): The hazel sticks were of uniform diameter; they were cut or torn from the hazel shrubs (Photo: H. Lübke; © LDA)

Figure 14.11 (bottom): To construct the fishing fence, 1- to 2-year-old branches of hazel were bound together with ropes of Acer cf. campestre *in a Z-manner. Larger branches were fixed to the smaller ones (Photo: R. Leineweber; © LDA)*

Archaeology

Expansion of the fishing fences

The first remains of the fishing fence were located approximately 400 m from the current shore in the northeastern part of Lake Arendsee. During the excavation campaign of 2005/2006, the course of the fence could be tracked and measured in a northeasterly direction for a distance of about 150 m where the feature lies some 300 m from shore. At the southwestern end, the fence remains occurred in a water depth of 11 m, protruding from a sloping scarp of the lake marl from *c*. 9 m to nearly 20 m deep. In contrast, in the northeast the fishing fence remains lie on the lake marl plateau above the scarp in a water depth of 9 m. At this site the lake marl is still being eroded over large areas by lake bed currents. As a result, the wooden fence exists here only in small parts where they have been preserved under large stones (Fig. 14.2).

In 2006 more remains of the fishing fence were discovered along the northwestern shoreline, although the information available is still preliminary. The fence was discovered at staggered depths of 3–7 m. This confirms that the localized lowering of the lake bed varied significantly within a relatively confined space in Lake Arendsee.

Construction of the fishing fences and wood analyses

The wooden structure, made of hazel (*Corylus avellana*), in the sediments of the Arendsee suggests the use of individual, prefabricated mats up to 1.60 m wide that were woven to 1.80 m long stakes. These were then fixed onto vertically exposed stakes in the lake. In the section

examined, these mats occurred in three layers embedded in the lake marl. The fence segments consisted of 1- to 2-year-old branches (twigs), which showed consistent growth. For the most part the stakes appear to have been cut, and only rarely show evidence of having been torn, from the bushes (Fig. 14.9). They indicate the use of coppicing practices during the 3rd millennium cal BC in the surroundings of the Arendsee.

The finds of the fishing fences in Lake Arendsee are the first evidence that coppicing was practised during the Late Neolithic in Saxony-Anhalt. The evidence also suggests that the shrubs were regularly and repeatedly cut to ground level. Consistently, the pollen diagram shows that hazel was prevalent and while its frequency varies, there is no clear evidence that hazel was overexploited. As the investigation of one sample suggested, the hazel stakes were bound with the phloem of maple (*Acer cf. campestre*) in a Z-turn (woven) connection. There were several instances of similar cords being found as small bundles adjacent to the fence segments. They probably served to connect the individual segments. Placed vertically (in relation to the horizontally-arranged hazel) larger stakes from 8- to 15-year-old hazel, and some stakes made of maple (*Acer platanoides/pseudoplatanus*), oak (*Quercus*) and ash (*Fraxinus*), provided stability (Fig. 14.10).

The mat-like fence elements appear to have been individually produced, connected, and attached to thin poles in the lake. In other, unexcavated locations, the scientific divers observed that some of the mats were fixed in place with large stones (usually three to five placed together) (Fig. 14.11). One can assume that the wooden fences were probably dismantled and the mats laid down on the lake bottom during the winter to protect them against damage by freezing or ice drift. Throughout its use, the originally upright structure was designed to guide fish near the shore, presumably into traps, though the position and shape of the traps are still unknown. Because of the length of the wooden sticks of the Late Neolithic fishing fence, one can assume a water depth of *c.* 1.5 m in this part of the Arendsee. As the fishing fence was likely built close to the former shoreline, its position gives an approximation of the Late Neolithic bank of the Arendsee. However, the lake was strongly influenced by subrosion and the lake bottom is presently much deeper than in the past. Therefore, the shoreline of the former Arendsee in the Late Neolithic period is still not known in detail.

Dating the fishing fence

The first excavation in the spring of 2005 produced a sample that gave an unexpectedly early ^{14}C age of 2680±130 cal BC (Erl-8019). This is the earliest date for an inland fishing fence from Germany, built by fishermen of the Late Neolithic Single Grave Culture. More ^{14}C dating of the finds (KIA-29663 to KIA-29670) gave ages up to 2120±60 cal BC (Table 14.1). They confirm the use of the fishing fences in the northeast part of Lake Arendsee over a period of at least 500 years, since the dates of the three levels of the feature are staggered (Fig. 14.12). The age

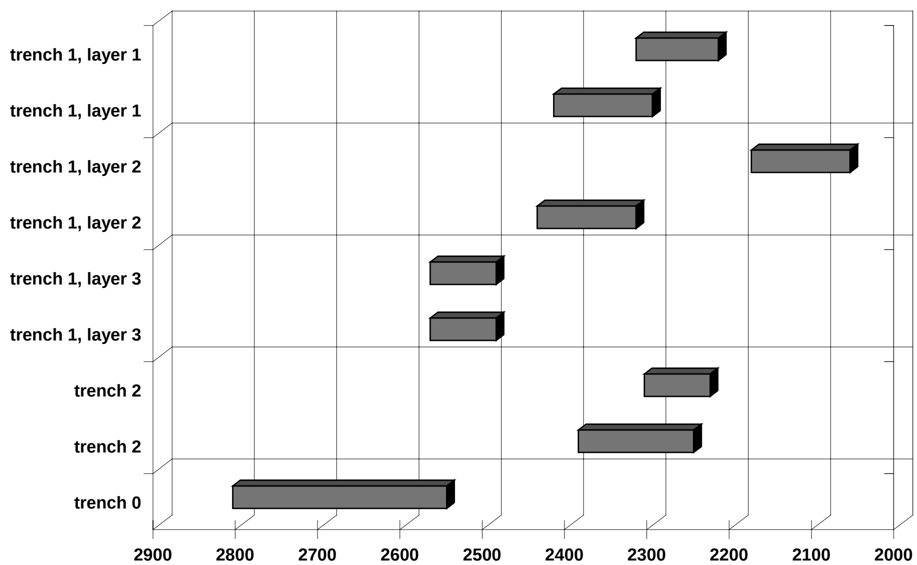

Figure 14.12: AMS ^{14}C dates (one-sigma calibrated age ranges BC) for the northwestern fishing fence with three layers (Drawing: M. Hellmund; © LDA).

of the fishing fence discovered in the northwest of the lake was determined to be *c*. 2400–2300 cal BC (KIA-31805 to KIA-31807).

The other ^{14}C results come from samples that were recovered during diving investigations in the vicinity of the excavation areas. On the lake marl a fragment of a fish trap was found (Leineweber and Lübke 2009a: fig. 8) and dated to the 9th century AD (820±40 cal AD, KIA-33276; Table 14.1), an indication of lake fishing in the Carolingian Period. At a depth of *c*. 6 m, modern pine poles were found stuck into the lake sediment, with axe-sharpened distal ends rotting above the lake marl (15th–20th century AD, KIA-33273 to 33275, 33277; Table 14.1). The data confirm the continuation of similar practices of net fishing for centuries along the northern shore of Lake Arendsee in historical times.

Biology

In 2008, 4 m^2 of the fishing fence and surrounding sediment, which were secured in four metal boxes, were taken into the lab for further analysis. Samples were also taken for pollen analysis. The sediments were wet sieved (mesh sizes were 2, 1, and 0.5 mm) and fish, snails, and plant macro-remains were recovered. In some cases 0.25 mm meshes were used. The sediments revealed abundant organic material: opercula from snails, remains of fishes, and plant material including roots. Many seeds, the majority from water plants, and some charcoal were also recovered, as were wooden artefacts.

Fish remains

The archaeozoological investigations revealed some dozen bones, teeth, and scales of fish. In all, four species could be determined: pike (*Esox lucius*), bream (*Abrama bramis*), perch (*Perca fluviatilis*), and pikeperch (*Stizostedion lucioperca*). Pike is the most frequent species in the assemblage, followed by perch. Bream and pikeperch are represented by only a single vertebra each. Today, three of the four fish species are present in Lake Arendsee, the exception being pikeperch, which is no longer present in this region (Döhle 2009). The pikeperch is generally found in eutrophic lakes with solid subsoil and murky water in summertime. It co-occurs with pike and bream, though they prefer other ecological conditions. Therefore, one may assume different ecological niches in the Arendsee. Probably, the ecological conditions of the Neolithic Arendsee were quite different than at present. The find of pikeperch in the Neolithic Lake Arendsee supports corresponding reports of this species from other Neolithic sites in northwest Germany, indicating that the Neolithic distribution area of this species extended further to the west than in later periods (Heinrich 1987: 148).

Plant macro-remains

Many botanical remains including seeds were documented in the sediments around the fishing fence. These contained a large number of fruit valves of the mermaid weed (*Najas marina*), the remains of pondweed (*Potamogeton* sp.), and *Ceratophyllum demersum*. Also present were oogonia of stoneworts (*Characeae*). The macro-remains indicate that the fishing fence was situated in a belt of submerged vegetation facing toward the open lake. Only some remains, like *Sparganium*, point to a belt of reeds, which would have been situated more in the direction of the lake shore. The only plant remains of land vegetation are the wooden remains of the fences and charcoal fragments. Owing to the presence of *Najas*, one may suppose that the lake water must have been relatively clear in the springtime. *Najas marina* is an annual species that prefers shallow water and a muddy substrate. Presently, *Najas* does not grow in Lake Arendsee and there is no botanical evidence of its former occurrence thus far. The archaeobotanical remains generally indicate eutrophic conditions in the Neolithic Lake Arendsee in the 3rd millennium BC, and that the fishing fence was built in an area of submerged vegetation near the former shore.

Other finds of fishing fences

The Late Neolithic fishing fence of the Arendsee is the first to be documented in Sachsen-Anhalt; however, there are comparable finds elsewhere. On the coast of Denmark several Neolithic fishing fences have been recorded. The locations of the stationary fishing weirs are marked by stable vertical posts and numerous semi-pointed stakes lying horizontally in the find layers. These features extended for up to several hundred metres (Pedersen 1995: 77). The best-preserved example is the Oleslyst fence where a 5.5 m long and 1.75 m high woven panel had collapsed and was embedded in marine deposits. Much information about raw material procurement and the construction of wattle work was gained from this site (Pedersen 1995: 78–80, 1997;

Fischer 2007). The fishing fences in Denmark were constructed of woven screens of hazel (*Corylus avellana*) rods. The horizontal rods were woven alternately around vertical stakes positioned *c.* 40 cm apart (Christensen 1997; Pedersen 1997). In contrast to the Neolithic fences, comparable structures of Mesolithic date seem to be smaller and were built of thin vertical posts. Concentrations of broken hazel rods in the shallow water zone adjacent to Mesolithic sites have been interpreted as destroyed fishing fences. Similar evidence is known from several places along the German Baltic coast, implying the former presence of Mesolithic fishing weirs also in this region (Mertens 2000; Klooß 2010).

At the Danish sites, the solid fishing structures of woven panels have been found in marine surroundings. In comparison, the fishing fence from Lake Arendsee was a more lightweight construction that could be arranged in a more flexible alignment and potentially used for several years. The construction consisted of thin parallel sticks, erected vertically and fastened with cords of maple phloem.

Very similar to the structure at Lake Arendsee are the fishing fences used in the 19th and 20th centuries AD in the tidal zone at the mouth of the river Elbe. These fences were composed of upright one-year-old rods of willow (*Salix*), bound together with thin willow twigs. The shoots were produced by pollarded willows growing in the wet river plains, and the fishing fences were re-erected every spring in the mud flats in a zigzag manner, combined with basket fish traps (Fig. 14.13). The 0.8–1.0 m high screens were fastened onto vertical posts with willow twigs and stabilized between two horizontal stakes. In the autumn, the screens were rolled up and brought to land. Some sticks were used again the next year but most were used as firewood (Danker-Carstensen 2002: 182).

Similar structures are known in Northeast Europe from the Neolithic onwards and were used for fishing in lakes and rivers; comprehensive information about fishing with fences is known from the Finno-Ugric people (Sirelius 1906). They built fences of split pinewood (*Pinus*) that was bound together in the previously described manner using different string material. The lath screens were erected in a straight line or a zigzag, ending in snail- or heart-shaped chambers, or were combined with basket fish traps. They were pushed into the mud, fastened on posts and stabilized by horizontal stakes (Sirelius 1906). From the Neolithic site of Sārnate in Latvia and from Šventoji in Lithuania bundles of pine laths bound with rope made of bast fibres are documented (Bērziņš 2008: 241, figs. 55–9; Rimantienė 2005: 71, fig. 177). These screens were also transported or stored in a rolled up condition as can be seen in photographs taken by fishermen in early 20th century Latvia – the fishing structures were erected in the spring and dismantled in the autumn to prevent breakage by ice drift (Ligers 1942; Bērziņš 2008: 246–50).

Figure 14.13: A historical photograph from the early 20th century showing fishermen, their wooden fishing fences, and a fish trap constructed of wood sticks (After Danker-Carstensen 2002).

Conclusion

At the end of the Funnelbeaker Culture in the Middle Neolithic, which is marked by monumental activities like the construction of megalithic graves, there was a massive economic and social upheaval. This is indicated not only by completely different patterns of settlement and burials, but also by new extensive subsistence strategies (cf. Dörfler and Müller 2008). Indeed, evidence is available that highly developed fishing techniques were already being implemented prior to the Middle Neolithic period in Denmark (Fischer 2007) and northern Germany (Lübke *et al.* 2007). But the several hundred metres long fishing fence from Lake Arendsee is the only find of its kind in German inland waters dating to the Late Neolithic, corresponding to the Single Grave Culture (3rd millennium cal BC).

The aforementioned comparisons lead to the interpretation that the Late Neolithic wooden

structures of Lake Arendsee were used as fishing fences. These fences show a practice that was often used, but which is rarely documented in inland waters. Abundant remains of *Najas* and *Characeae* and some seeds of *Potamogeton* and *Ceratophyllum* indicate that the fishing fence was situated in a belt of submerged vegetation near the lake shore or in shallow waters, though the configuration of the Neolithic shoreline is still not known in detail. One may suppose that in Neolithic times the fish were directed along the fishing fence toward a trap. Interestingly, the sediments close to the Late Neolithic fishing fence revealed rare fish remains. The fishing fence may have prevented fish from reaching the area of reed vegetation for spawning or feeding. Contemporaneous fish traps have not yet been found in the Arendsee.

Lake Arendsee was formed through 'lake collapses'; hence it offered the unique possibility to explore an alternative economic strategy by giving insights into systematic, large-scale, passive fishing. However, remains of a contemporaneous settlement on the bank of the lake have not yet been recorded and only isolated ceramic fragments from the Single Grave Culture are known from the wider region around the Arendsee. In the entire Altmark region the Single Grave Culture is represented mainly by individual finds of stone axes and flint artefacts from graves, either secondary burials in megalithic graves or single graves. Closed grave finds are rare and settlement sites with organic artefacts are so far unknown. The discovery of the Late Neolithic fishing fence in the Arendsee in Sachsen-Anhalt was accidental, and the investigations of this extraordinary find and its context are still in progress.

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A Palaeolithic Wooden Point from Ljubljansko Barje, Slovenia

Andrej Gaspari, Miran Erič and Boštjan Odar

In September 2008, underwater archaeologists discovered a pointed wooden object in the Ljubljanica River near Sinja Gorica in Ljubljansko barje (Ljubljana Moor). Its shape is reminiscent of Palaeolithic leaf-shaped stone and bone points. Two wood samples were dated using the AMS ^{14}C method. The first gave an age of >43,970 years, while a repeat measurement gave 38,490±330 BP. The wooden point was made and used around the time the Neanderthals were gradually becoming extinct and the first anatomically modern humans were beginning their journey from the Middle East to Europe. The Ljubljanica site thus joins four other European sites that have produced remains of wooden hunting weapons dating to the Palaeolithic (Clacton-on-Sea, Lehringen, Schöningen, and Mannheim).

Keywords: Palaeolithic, wooden point, underwater archaeology, Ljubljansko barje, Slovenia

Introduction

Little is known of the wooden material culture of Palaeolithic communities in Europe. Remains of Palaeolithic lances have so far been discovered at Clacton-on-Sea (England) (Oakley *et al.* 1977), Lehringen (Germany) (Junkmanns 2001: 6) and Schöningen (Germany) (Thieme 1999), while the remains of a Palaeolithic bow were found at Mannheim (Germany) (Rosendahl *et al*. 2006). Of these finds, only the Mannheim bow was dated directly, giving an age of *c*. 17,700 BP, while the wooden lances were dated indirectly. The four European sites with remains of Palaeolithic wooden hunting weapons are now joined by a new find of a wooden tanged point from the Ljubljanica River, Slovenia, that was made and used *c*. 40,000 years ago when Neanderthals were in decline, but several millennia before anatomically modern humans appeared in Europe.

Circumstances of discovery of the wooden point

In September 2008, the Underwater Archaeology Workgroup of the Institute for the Protection of Cultural Heritage, in cooperation with the Regional Office, Ljubljana, conducted a preventive survey of the right half of the Ljubljanica riverbed near Sinja Gorica (Fig. 15.1). During manual removal of a layer of sandy silt with organic detritus that covered the geological basement of grey to light brown silty clay and sandy silt, the conservator Miran Erič discovered an isolated wooden object, apparently unassociated with structures or contemporaneous objects. Its symmetrical shape immediately attracted attention (Figs 15.2 and 15.3). The research group then invited Boštjan Odar, a specialist on prehistoric hunting equipment and techniques, to examine the object; he concurred with the observation of the excavator and

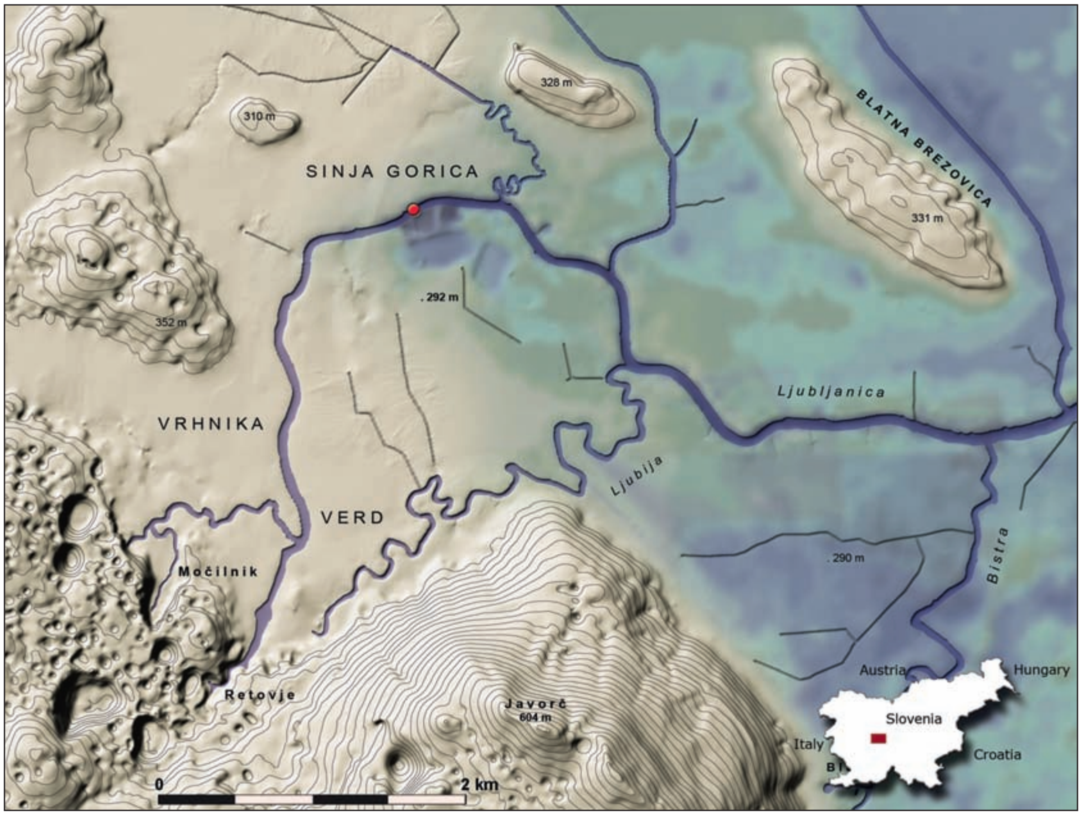

Figure 15.1: The find location in the western part of Ljubljansko barje

compared the find's shape to various leaf-shaped stone and bone points from the Late Mousterian of Central Europe.

The find location is *c*. 2 km downstream from the karst springs of the Ljubljanica, on the western edge of Ljubljansko barje. Several hundred metres downstream from the springs the carbonate bedrock falls to a depth of *c*. 21–28 m, while the river enters an area with a sequence of mostly fine-grained sediments deposited at the end of the Last Glaciation and during the Holocene (Mencej 1990: 526, figs 1–2). The present course of the Ljubljanica is relatively recent and dates from the Bronze Age (Gaspari 2009: 40). Today, it is a low-energy, lowland river with a low gradient (0.01 m per km) and material predominantly transported in suspension (<0.063 mm). At Vrhnika its average annual flow is 24.3 m^3/s. Its width at the find spot is *c*. 25 m and the depth *c*. 8 m; it has steep banks and a relatively flat bottom (282.2–283.7 m ASL), while it is flanked on both banks by natural levees that run into the floodplain (290–292 m ASL). In the late 19th and early 20th centuries the plains to the north and south of the river were exploited for the extraction of grey sandy clay for the local brickworks. The resulting pits on the right bank, which are up to 10 m deep, are now filled with water and turned into ponds, and are parallel with and upstream from the site.

The discovery of a wooden point dated to >37,000 years BP in the riverbed of the Ljubljanica can be explained in a number of ways. The first is that it was derived from the erosion of earlier sediments in the riverbed or at the base of the riverbank, and the second is that it originated from deeper-lying sediments of the nearby clay pits, whence it later came into the Ljubljanica. In order to test these hypotheses, samples were taken from the sediments at the find spot and later submitted for OSL dating. After removing several centimetres of the surface layer at the riverbed, a 35 cm thick sample of sandy clay was taken at 283.2 m ASL, where the river was 2.8 m deep. The analysis of 47 aliquots was performed giving dates ranging from 17,600±1600 to 9000±1300 BP, which shows that the sampled sediments were deposited between the beginning of the Late Glacial and the Early Holocene. The OSL analysis of the sediments combined with the isolated position of the find led to the conclusion that the point was not *in situ*, but found its way into the

Figure 15.2: Photographs of both faces of the wooden point from the Ljubljanica River near Sinja Gorica

Ljubljanica riverbed during the excavation of the deeper-lying layers in the nearby clay pits. However, the changing dynamics of tectonic subsidence and compaction of the layers in the Ljubljansko barje do not allow us to exclude the possibility of the point being exposed by erosion of the sediments lying upstream.

Description of the find

The object measures 16 cm long, 5.1 cm wide, with a maximum thickness of 2.5 cm, and its symmetry is apparent from all views and cross-sections. Lengthwise, it is thickest in the centre, whence it tapers evenly toward both ends. In cross-section it has a flattened oval shape. The base is damaged at the transition to the tang. The determination of the wood as yew (*Taxus* sp.) was performed by Martin Zupančič, expert adviser from the Department of Wood Technology of the Biotechnical Faculty at the University of Ljubljana. The juvenile wood shows pith, while the tree rings are clearly discernible, thin, and slightly wavy.

Soon after discovery, the object's similarity in shape and size to leaf-shaped stone points (cf. Bosinski 1967) was noted. The chronological attribution of the object to the Late Mousterian on the basis of typological characteristics was confirmed by radiometric analyses using the AMS ^{14}C method. The first date, provided by the Miami laboratory, showed the wood to be >43,970 BP (Beta-252943), while repeat dating gave an age of 38,490±330 BP (OxA-19866). Interestingly, the leaf shape of stone points was also imitated by certain bone points from Mokriška jama, Slovenia (Odar 2008: 31–7), and from the Vindija Cave, Croatia (Karavanić 1993) where bones of cave bears and Neanderthals from Layer G1 were dated to 33–32,000 BP (Smith *et al*. 1999; Wild *et al*. 2001; Higham *et al*. 2006).

Several lines of evidence indicate that the object was made intentionally and not shaped by natural processes. First, it is the only symmetrical find among a mass of wooden material uncovered by underwater archaeologists after more than 15 years of researching sites in the Ljubljanica and its tributaries. Secondly, there is evidence that it has been deliberately shaped – a little branch close to the tip had been cut or ground down so that it did not protrude from the surface; there are cuts perpendicular to the fibre-axis at the base of the tip, and the symmetrical narrowing towards the point does not follow the grain of the wood (information from Niels Bleicher of the Labor für Dendrochronologie in Zürich). Thirdly, the fact that it was made of yew provides further proof of its cultural origin. Yew is a mesophile species that thrives on fresh, humus-rich and aerated soils, preferably on limestone bedrock, but is not suited to sandy soil (Brus 2005: 116–17). It characteristically grows in cool, shady locations in birch and mixed-coniferous forests as well as in maple and elm forests. Yew trees grow in river gorges, on poorly accessible rocky faces and humid northern slopes, but they are not found on humid banks of lowland rivers and floodplains, as is the case of the Ljubljansko barje. Fourthly, there is evidence that it was fire hardened. One face of the object shows signs of abrasion from fine particles in the riverbed, but the other face is almost completely covered by

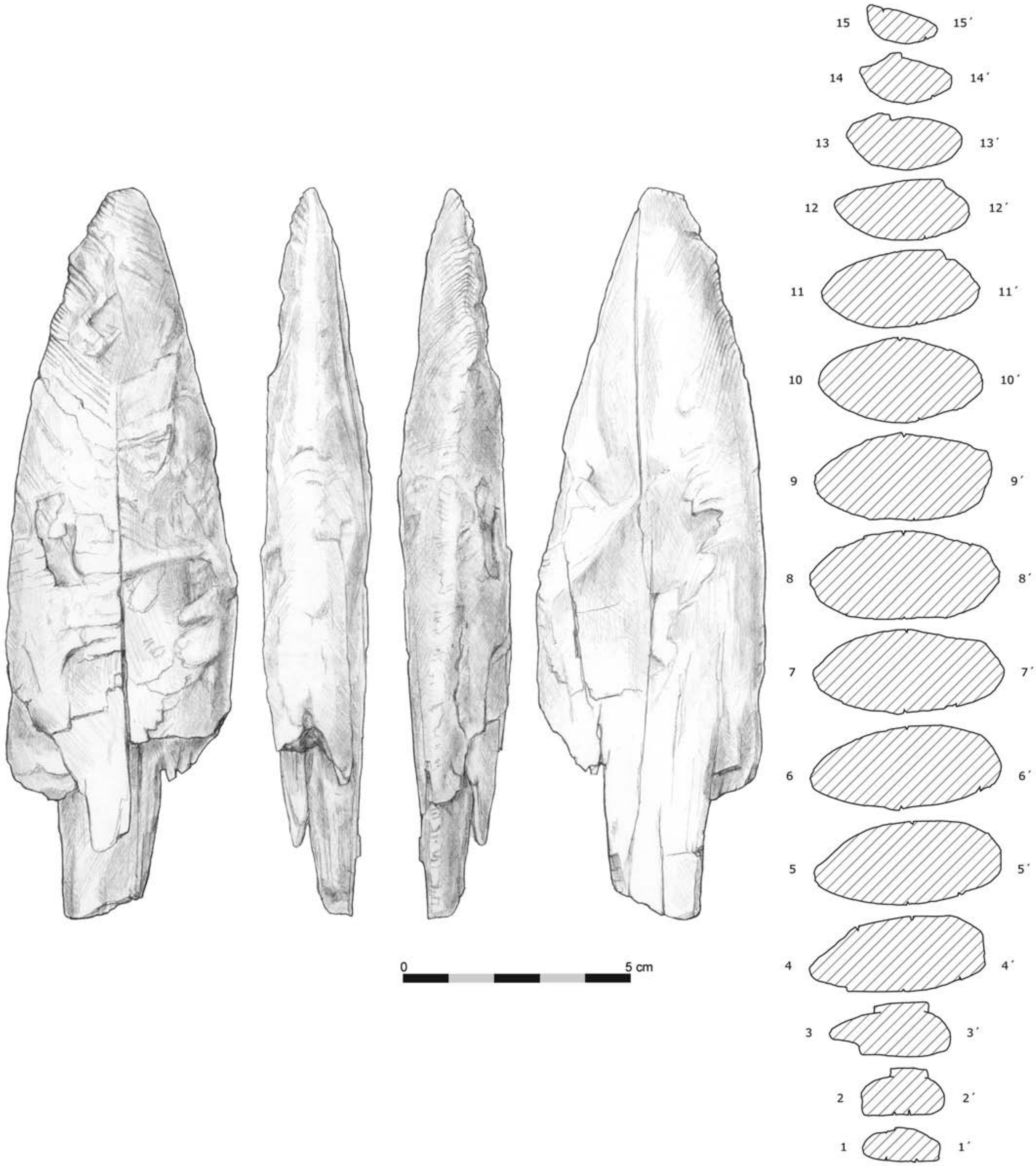

Figure 15.3: The wooden point drawn from different views

a 0.2–2 mm thick, compact, black material that is partly cracked, smooth, and has a desiccated appearance. This material was analyzed using SEM–EDS by Ivo Nemec from the Restoration Centre of the Institute for the Protection of Cultural Heritage of Slovenia and shown to be wooden with *c*. 30% of carbon and 65% of oxygen content. This indicates that the surface of the point had been burnt, and suggests fire hardening. Previous research has shown that yew wood becomes several times harder when exposed to fire, compared to other wood species that harden only minimally (Fehrenbacher 2007). This also explains why the traces of wood-working on the points from Schöningen are extremely well preserved (Thieme 1997, 1999). Those points were made from wood of a much poorer quality, namely spruce and hazel, and would have required repeated sharpening. They therefore reveal traces of the last rather than the first sharpening before being lost or discarded. The process of fire hardening would cause such traces to disappear and would account for the lack of resharpening marks on the Ljubljanica point. Additional evidence of its deliberate shape is visible on the lower part of the point, where it has a pronounced shoulder transition from the widest part into the tang. The latter enabled the point to be hafted onto a notched, long shaft. A break is visible on the tang of the point, but it is uncertain when this occurred. Such breakages are usually caused by bending overload on the junction of the wooden shaft at the point of attachment (Odar 2008: 140–69).

Other Palaeolithic finds in the area

The early prehistory of Ljubljansko barje is known among the archaeological community and the general public primarily for its traces of human settlement and exploitation of the natural environment during the Holocene. In recent decades archaeological investigations have been concentrated on Mesolithic sites on isolated hills and peripheral areas of the moor, and particularly on pile-dwelling settlements on the floodplain dating to the period between the Late Neolithic and Early Bronze Age (Velušček 2004). However, it is certain that the biotic diversity of the tectonic depression and surrounding hills, a 163 km^2 area at the junction of the Alpine and Dinaric zones, also attracted people in earlier periods. Yet their presence in the area between Vrhnika, Ljubljana, and Ig has only been documented through individual finds that lack clear archaeological contexts.

Until recently the record of the Palaeolithic from Ljubljansko barje was limited to chance finds, although it included a find of a reindeer (*Rangifer tarandus*) antler from the clay pits of the Petrič brickworks northeast of Vrhnika. This find is currently lost but is known to have been covered with incisions (Hilber 1906). A Mousterian concave-straight side-scraper was found on the nearby hill of Hruševca (Snoj 1987), but there is also an unverified record of an open-air site on a terrace in the vicinity of Brezovica (Brodar 1981: 195–6). The earliest sites documented in the area of the floodplain are Early Holocene camps at Breg near Škofljica (Mlekuž 2001) and Zalog near Verd (Gaspari 2006). Consequently, one can only speculate about the archaeological potential of deeper lying sediments. The earliest sediments, infilling the over 170 m deep tectonic-collapsed doline of Ljubljansko barje, belong to the transition from the Lower to the Middle Pleistocene, *c*. 800,000 years ago. The stratigraphic sequence is dominated by Late Pleistocene sediments formed in different fluvial environments, with repeated appearances of a lake and of a marsh. The last lake formed as a consequence of the deposition of the alluvial gravel cone of the Sava River, which closed off the outlet of the predecessor of the Ljubljanica River through the straits between the hills of Rožnik and Grajski Grič during the Last Glacial Maximum (MIS 2) and its immediate aftermath, *c*. 22–14,000 BP (Verbič and Horvat 2009: 13–15, figs 4c and 6).

Conclusion

The wooden point is evidence of the presence of Ice Age hunters on Ljubljansko barje during the time of the gradual decline of Neanderthal populations, whose existence came to an end a few millennia later after the arrival of anatomically modern humans in Europe (Zilhão and D'Errico 1999; Bar-Yosef and Zilhão 2006).

The pollen record of Ljubljansko barje reflects its refugial nature during MIS 3–5 of the Last Glaciation. During stadial periods, the main tree species were *Pinus*, *Betula*, *Picea* and *Abies*, but also thermophilic deciduous species (*Alnus*, *Quercus*, *Tilia*, and even *Fagus*). Even during the LGM, when the closest glaciers were only 30 km away, the sediments of the barje show

pollen of *Pinus*, *Alnus*, and dwarf species of *Salix* and *Betula* (Pohar *et al.* 2002: 199). The warmer phases of the Last Glaciation (MIS 3–4) saw the deposition of layers of carbonate clay as well as gyttja and organogenic detritus in the tectonic depression of the barje, which point to occasional lakes, marshes, or even periods of dry ground, while waterways deposited thicker or more coarse-grained alluvia during colder periods or stormy conditions.

The concentration of palaeontological and archaeological finds from the 'Old Stone Age' in the northwestern periphery of Ljubljansko barje may be connected with the topographically favourable route across the lowest part of the massif between the Ljubljana Basin and the hinterland of the northern Adriatic, but also to the abundance of fresh water from karst springs and surface influents. The overlapping of the established intra-regional routes of hunting groups and water sources, which attracted large mammals, might also be indicated by the report of recurring animal bones, recovered without context, in the clay pits near Vrhnika (Hilber 1906). In light of the above-mentioned factors, the original context of the wooden point might be assumed to have been a campsite, an accidental hunting loss, or an animal kill-site (cf. Churchill 1993).

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16

Investigating the Submerged Prehistory of the Eastern Adriatic: progress and prospects

Jonathan Benjamin, Luka Bekić, Darko Komšo, Ida Koncani Uhač and Clive Bonsall

In this paper we assess the potential for the survival and investigation of submerged prehistoric sites and cultural landscapes in the eastern Adriatic. We review previous underwater prehistoric finds from the region and evaluate their significance. Most of these finds were made in shallow water close inshore and likely date to the Neolithic–Early Bronze Age. We discuss the reasons for this pattern and for the concentration of finds along the Istrian and Dalmatian coasts. The prospects for finding submerged sites belonging to earlier periods of prehistory are discussed, with emphasis on the crucial period between 7000 and 5500 cal BC during which farming and herding supplanted hunting, fishing, and gathering as the dominant modes of subsistence. Against this background, we present a research design for a multidisciplinary study of submerged landscapes around one of the larger islands of the Zadar archipelago. It is suggested that some important questions of the processes and timing of the transition to farming around the Adriatic Basin may only be answered through the investigation of the continental shelf, and that such research can also contribute to a better understanding of Holocene sea-level and coastal change.

Keywords: eastern Adriatic, sea-level rise, submerged cultural landscapes, Mesolithic–Neolithic transition

Introduction

Underwater archaeological investigations along the eastern Adriatic coast traditionally have focused on Classical, maritime, and shipwreck archaeology (cf. Jurišić 2000; Radić Rossi *et al.* 2008; Bekić 2009a). However, the region has a rich prehistory and studies of post-glacial sea-level change and shoreline displacement suggest there is potential for the discovery of underwater prehistoric sites dating back to the Early Holocene or even the Late Pleistocene, at locations and depths that are accessible to archaeological divers. Since relative sea level along the eastern Adriatic rim is higher today than at any stage of prehistory, many low-lying coastal sites must have been transgressed. Dalmatia, in particular, with its varied coastal landscape comprising thousands of islands, protected embayments, straits and, importantly, submarine caves, is a region of high potential for underwater site discovery. In this paper we review past research into the submerged prehistory of the eastern Adriatic Sea, reporting on some previously unpublished finds. We also discuss the prospects for future research aimed at recovering new evidence from the seabed that could revolutionize our understanding of some of the key events in the prehistory of the region, such as the introduction and spread of farming.

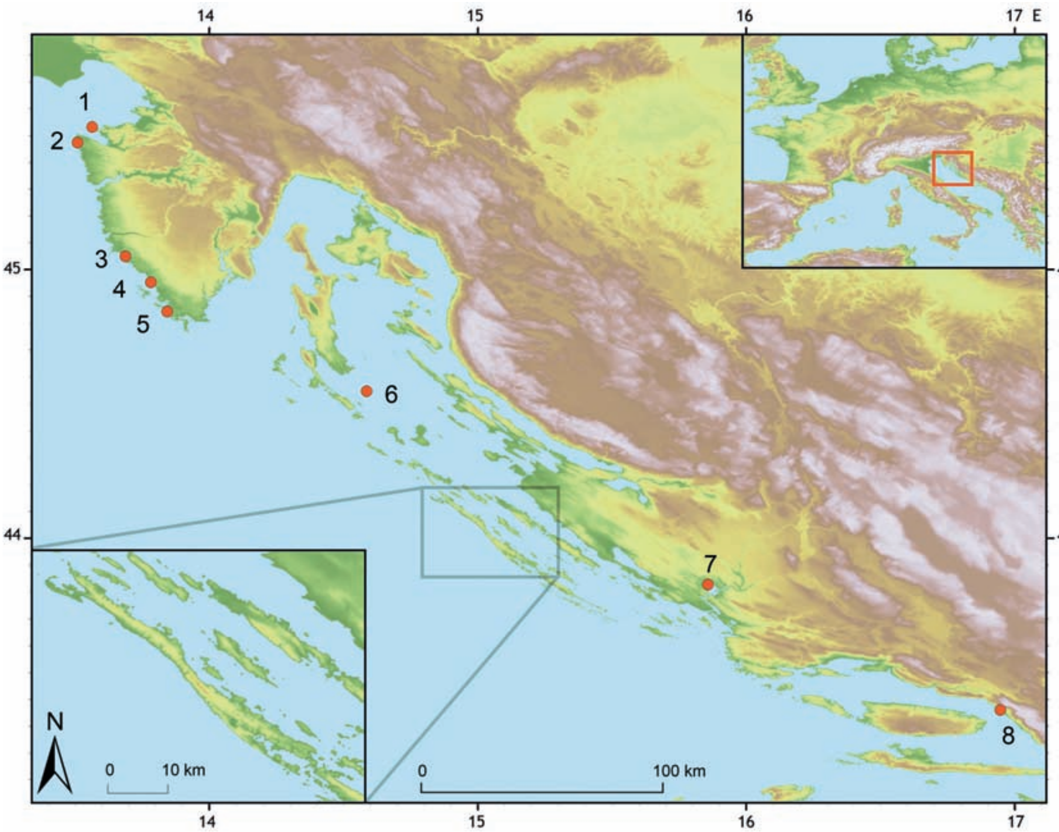


Figure 16.1: Locations of underwater prehistoric finds from the eastern Adriatic. 1 Punta Piran, 2 Zambratija Cove, 3 Veštar Bay, 4 Cap Gale, 5 Veruda Bay, 6 Oruda, 7 Stipanac, 8 Baška Voda (SRTM digital elevation data, after Jarvis et al. *2008)*

Previous finds

At least eight submerged sites or localities with prehistoric artefacts have been reported along the eastern Adriatic coast between Piran in Slovenia and Makarska in Croatia (Fig. 16.1).

Punta Piran

The only well-documented prehistoric find from the Slovenian sector of the Adriatic Sea was a single chert artefact recovered from the seabed at 26 m depth in front of the headland of Punta Piran (Fig. 16.1). It was found in 2005 during an underwater survey directed by Jonathan Benjamin (Benjamin 2007; Benjamin and Bonsall 2009a). The artefact, described as a small bifacial dagger or 'fixed blade' knife (Fig. 16.2), compares closely in form and raw material to northern Italian Chalcolithic and Bavarian Final Neolithic examples, and probably originated in the northeast Italian Pre-Alpine region. The depth at which the artefact was found suggests it was not in a primary context, or was lost at sea during its time of use (for discussion, see Benjamin and Bonsall 2009b).

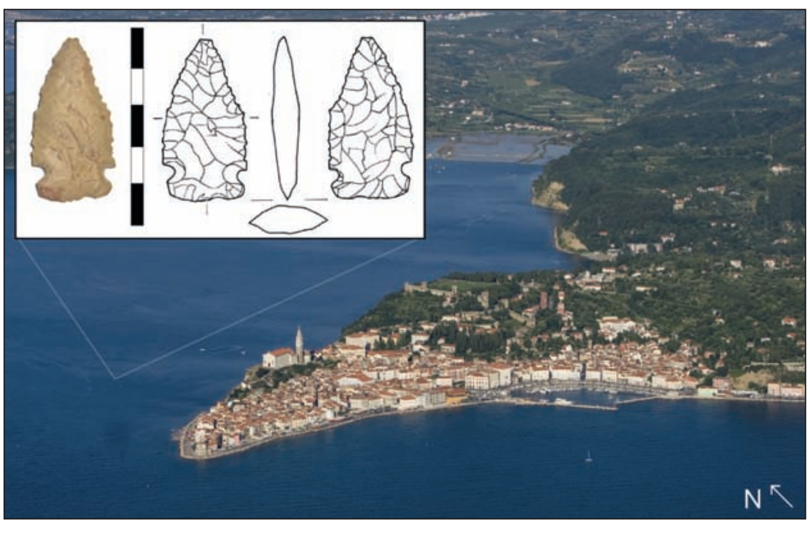


Figure 16.2: Punta Piran, Slovenia. The bifacial dagger blade found during underwater survey in 2005 (Photo: J. Benjamin)

Zambratija Cove, Savudrija

In September 2008, the Archaeological Museum of Istria (Pula) began an underwater rescue project around the Bay of Zambratija in northwestern Istria, not far from Savudrija (Fig. 16.1; Koncani Uhač 2009). While excavation of a shipwreck was in progress along the southern shore of the bay (Fig. 16.3), a survey of the northern shore was conducted. It was here that wooden remains were observed (Fig. 16.4). In places the timbers protruded from the sandy seabed sediments, forming a more-or-less circular pattern.

Figure 16.3: Zambratija Cove. The submerged prehistoric site is located in the northern part of the bay (Photo: J. Benjamin)

A 2 × 1 m test-pit was excavated where the wood remains were most densely concentrated. The seabed in this area is composed of sand and seagrass and the top of a round wooden post was visible at an absolute depth of 2.36 m. After removal of the seabed sediments with a hand-held water dredge, a 5 cm thick layer of grey mud containing traces of burning was encountered; the top of the wooden post also exhibited signs of burning. Pottery sherds and animal bones were found in this grey mud layer. Below the grey mud was a 0.54 m thick layer of fine, compact, darker grey mud with numerous sherds of prehistoric pottery and bones of cattle, small game, and fish. Within this layer four vertically placed posts, with two posts lying diagonally between them, were documented. Underneath the posts, at an absolute depth of 3.09 m, horizontally aligned timbers – thought to be the remains of a house floor – were uncovered. Since the field research was time restricted, the excavation was suspended at this point and the site protected with geotextile in accordance with standard archaeological practice. The archaeological materials recovered were sent for specialist analyses, and samples of bone and wood were taken for ^{14}C dating.

Underwater survey revealed a total of 34 wooden posts over an area of approximately 6500 m². The archaeological remains occur between 2.4 m and 3.1 m absolute depth. Preliminary analysis of the pottery suggests the site belongs broadly to the time-range from the Middle Neolithic to the Early Bronze Age.

The discovery of the site at Zambratija raises questions about the human consequences of the Holocene marine transgression in the eastern Adriatic. Was the transgression the primary reason for the abandonment of the site? Was the site built directly adjacent to the shore, or even partially (or entirely) above water? Or was the site located some distance from the actual shore during its occupation? Further investigations at Zambratija Cove, and research into regional sea-level change are needed if these questions are to be answered.

Veštar Bay

Veštar is a large bay with a flat, shallow bottom just a few metres deep (Fig. 16.1). Previous underwater finds from the bay include Roman, Medieval, and Post-Medieval artefacts, and the remains of a Roman stone-built breakwater (Bekić 2001, 2009b), although prehistoric sites are known from the surrounding area (Bekić 1996; Komšo 2008).

Underwater surveys directed by Luka Bekić between 2000 and 2009 recovered five pieces of chert from the seabed, from a zone extending for about a hundred metres along the southern shore of the bay. No prehistoric pottery was found in this area, although local informants have reported finding more chert – including a distinctive red-brown variety (see below) – on the adjacent beach. The chert pieces (Fig. 16.5) were found at absolute depths of between 1.5 m and 2.5 m; three were found directly on the seabed, and the other two in loose sediment just below the seafloor. The condition of some of the chert pieces and the contexts in which they occurred suggest they were not in a primary position.

A preliminary analysis (by Darko Komšo) suggests that at least one of the chert pieces is an artefact (Fig. 16.5, 3). This is a fragment of a bladelet with abrupt retouch along one lateral edge and traces of 'sickle gloss' along the opposing edge. Similar finds are known from Neolithic and Copper Age sites (Chalcolithic, also known as Eneolithic) in the region (cf. Codacci 2002; Komšo 2004; Forenbaher and Nikitović 2007; Komšo *et al.* 2009). None of the other four chert pieces shows clear signs of working. The largest piece (Fig. 16.5, 1) – a

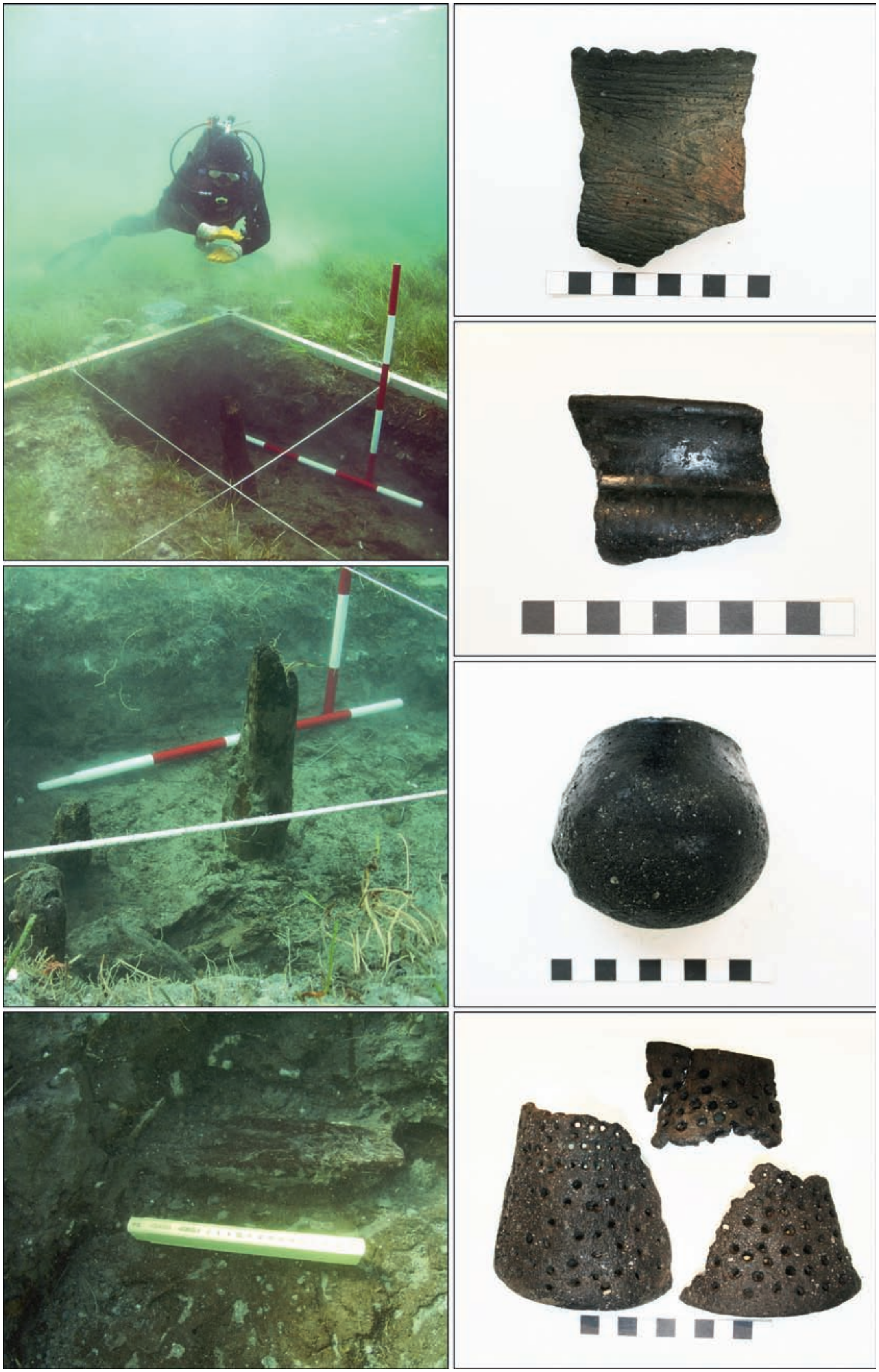


Figure 16.4: Images of the prehistoric site in Zambratija Cove and examples of pottery from the grey mud layer (Photos: I. Koncani Uhač)

fragment of a nodule with pale-brown 'chalky' cortex – exhibits a number of mechanical fractures, although none of these is necessarily man made. The material is dark red to brown in colour, and of high quality. No outcrops of this type of chert are known from Istria (cf. Pellegatti 2009), and it is almost certainly from an exogenous source, most likely northern Italy (Scaglia Rossa or Scaglia Variegata). The second largest piece (not illustrated) is probably the same type of chert, but is heavily burnt with thermal fracture scars. Unlike the first three pieces described, the remaining two (Fig. 16.5, 2, 4) show signs of water abrasion suggesting long exposure to wave action. The larger of these is also probably non-local chert, but from an unknown source. Superficially it resembles a core fragment, although the degree of abrasion makes it difficult to tell if this is an artefact or an unworked nodule fractured by natural processes.

The presence of three chert objects from (apparently) non-local sources raises the question of how they reached Veštar Bay. Were they brought there by prehistoric people, e.g. as raw material, or were they ballast stones from ships entering the bay?

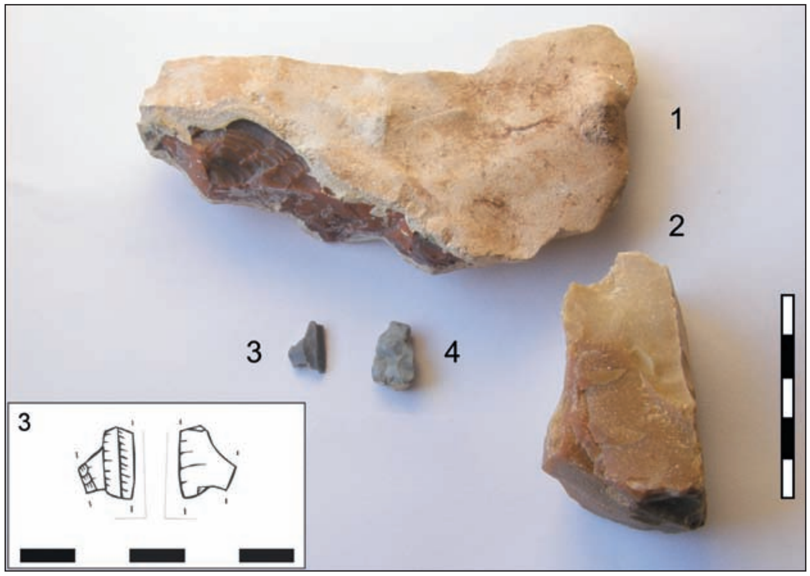


Figure 16.5: Lithic material recovered from Veštar Bay (Photo: L. Bekić)

Cape Gale near Peroj, Istria

In 2004 a small-scale survey was conducted along the coast of Cape Gale near Peroj (Fig. 16.1). This led to the recovery of a large chipped stone assemblage. Initially, material was collected on the gravel beach. During subsequent surveys, however, it was observed that at low tide numerous stone, pottery, and faunal remains could be found on the seabed at depths of up to 50 cm. In spite of these observations, no underwater survey has yet been undertaken, and the extent of the submerged part of the site is still unknown. A total of *c*. 500 chert and other stone tools were collected, among which are ground-edge tools, and numerous chipped stone tools and debitage. They include arrowheads, end-scrapers, piercers, and prismatic blades. Although the pottery from the site is very eroded and fragmented, 'brushed decoration' is still visible on the surface of some sherds. The chipped stone tools and pottery can be dated typologically to the period from the Late Neolithic to the Early Bronze Age. The evidence points to the existence at Cape Gale of at least a partially submerged prehistoric site.

Veruda Bay, Pula

Veruda bay (Fig. 16.1) is a narrow inlet about 2 km long, which separates the town of Pula from the southernmost part of Istria. The bay is generally less than 2 m deep and, being surrounded by hills, is relatively sheltered from winds from most directions. During the 1980s the Marina Veruda was built in several phases along more or less the entire eastern shore of the bay. Construction of the marina required deepening of the harbour. Soft sediments dredged up from the seabed over an area *c*. 250 × 100 m in the inner part of the bay were deposited on land at the head of the bay. A diverse assemblage of prehistoric and Roman pottery sherds, stone artefacts, and animal bones was later recovered from this redeposited material, and presented to the Archaeological Museum of Istria in Pula (Mihovilić 1992). Among the lithics are two polished axe-heads made from volcanic rocks (one complete, the other a proximal fragment of a shaft-hole axe) and chipped stone artefacts made from local (central Istrian) dark grey to black chert, including side- and end-scrapers, piercers, backed tools, a bifacial leaf-shaped point (interpreted as a spearhead or dagger blade), and long prismatic blades. Although likely a mixed assemblage, the lithic artefacts were compared to those from Neolithic–Early Bronze Age sites in the northern Adriatic region by Mihovilić (1992: 87–8), while Bernadini *et al.* (2009) attributed the shaft-hole axe more precisely to the Copper Age.

Oruda

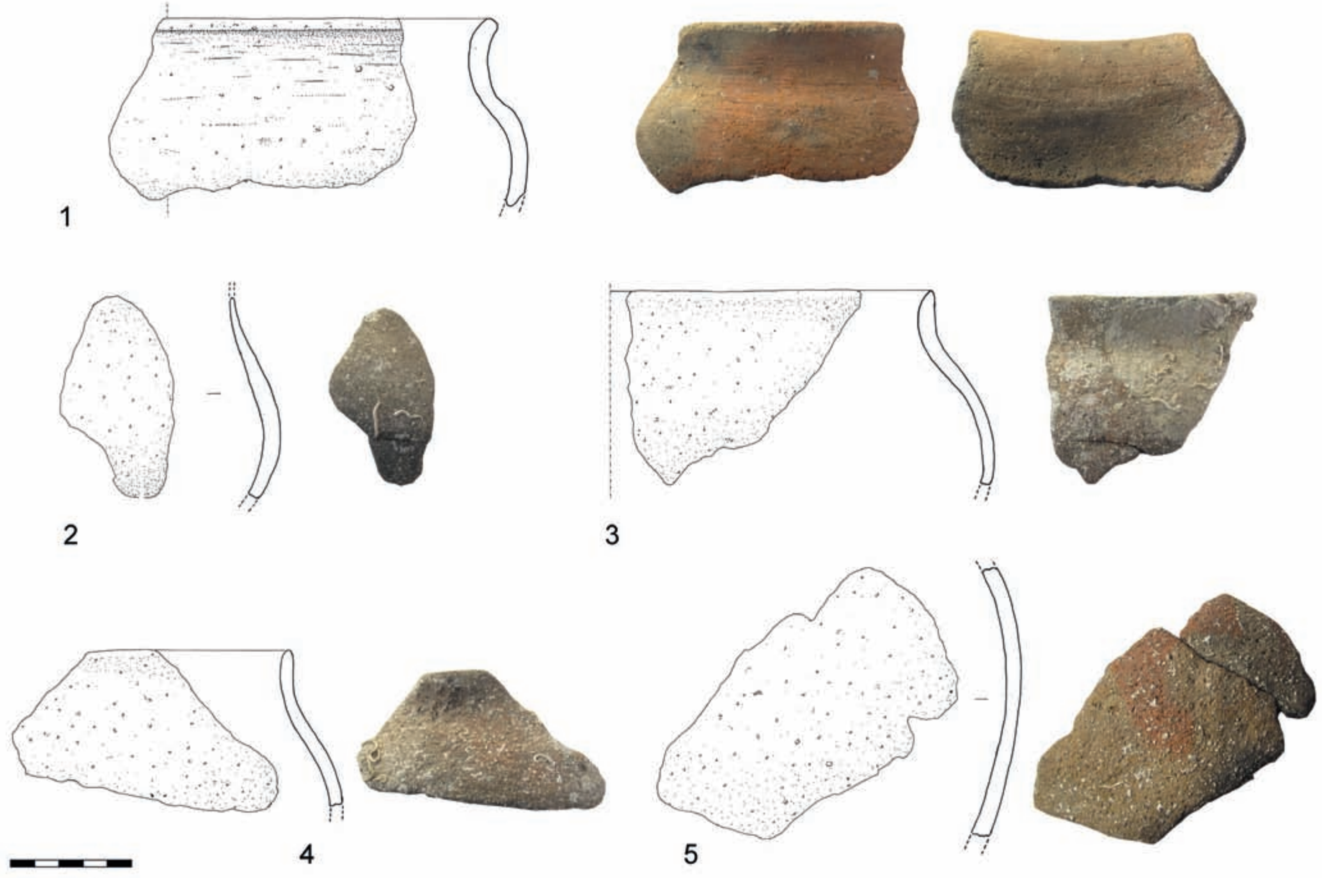
To the south of the small island of Oruda (Fig. 16.1) west of Lošinj, there is an islet, called Palacol. During the investigation of a Post-Medieval wooden shipwreck in the summer of 2010 pottery sherds were discovered at a depth of *c*. 5 m. The location of the shipwreck is *c*. 100 m south of Oruda and *c*. 50 m north of an unnamed rock protruding from the sea. About a dozen of the sherds (Fig. 16.6) are thought to be of a prehistoric origin, and therefore unrelated to the shipwreck. Most of the ceramics were found directly on the seabed, and were abraded owing to the strong currents at this location. They are hand made, unevenly fired, with crushed calcite temper. Three sherds are from vessels with a wide, rounded body, a horizontal, nearly straight, cylindrical neck, and a very slightly everted rim (Fig. 16.6, 1, 3) or non-everted, straight rim (Fig. 16.6, 4). One potsherd (not illustrated) has no calcite temper, but is also likely to be prehistoric. None of the sherds bears traces of ornamentation. Typologically, the sherds are typical of the Copper Age in the Istria and Kvarner regions. The best-preserved piece (Fig. 16.6, 1) was excavated with a dredge from underneath the shipwreck – an indication that there may be other well-preserved artefacts in the seabed sediments.

Some 30 m to the west of the shipwreck a linear stone feature, approximately 10 m in length, protrudes from the sandy seabed. Given its depth below sea level this is also likely to be prehistoric, perhaps the remains of a wall or causeway between Oruda and the rock to the south.

Zadar–Šibenik (Stipanac)

Brusić (1977) reported the first underwater finds of prehistoric artefacts along the east Adriatic coast in a publication that focused primarily on later material. He described the results of underwater surveys along the coast between Zadar and Šibenik in central Dalmatia (Fig. 16.1). Prehistoric pottery and chipped stone artefacts were recovered from the seabed, usually in close proximity to islets just offshore, although few details of the finds or their contexts are

Figure 16.6: Prehistoric ceramics found near Oruda (Photo: L. Bekić)



available. A series of chert artefacts found on the seabed near Stipanac islet were identified by Brusić (1977) as 'Palaeolithic', and more precisely by Malez (1979) as 'Mousterian'. However, these chronological interpretations cannot be verified on the basis of the published descriptions or illustrations (Fig. 16.7).

Baška Voda

In 2002 non-archaeological divers recovered a small group of lithics from the seabed near the Dalmatian coastal town of Baška Voda (Fig. 16.1). The objects were discovered when efforts to dislodge a boat that had run aground in the harbour resulted in a 'trench' some 30–40 cm deep in the seabed. The find spot was recorded as approximately 50 m from the shore (now a harbour wall), roughly in the centre of the harbour. The lithics are reported to have been found at a depth of *c.* 5–6 m (T. Jurišić, pers. comm. 2009), but no information is available on their geological context – thus, it is not known if, prior to disturbance, they lay in the reworked sediment on the seabed or were stratified in an older, pre-transgression deposit. They were reportedly found together as a group, and show no signs of natural abrasion caused by stream or wave action. Whilst this might suggest they were *in situ* or had not moved far from their original place of deposition, it does not exclude the possibility that they were redeposited in containing sediments during harbour construction or operations. Another possibility is that the lithics were intentionally deposited in the sea, either as refuse or as a ritual act. Some sherds of Roman pottery were also found in the vicinity, but where these occurred in relation to the lithics and whether they were deposited at the same time, which would imply secondary deposition of all the material, is not known.

Of the six lithic pieces recovered, five are now housed in a private collection in Baška Voda, where they were examined and photographed by Jonathan Benjamin (Fig. 16.8). They comprise two prismatic blades, an amorphous core, a fragment of a ground-edge implement, and an unworked chert 'chunk'. The longer blade (Fig. 16.8, 1a–d) is *c.* 19 cm long, tapers to a point, and is made of reddish-brown chert. There is light retouch along the distal half of one edge, resulting in a slightly denticulated edge outline. Both lateral edges show slight rounding probably caused by use or hafting since the dorsal ridges are sharp. This piece may have served as a knife blade. The shorter of the two blades (Fig. 16.8, 3a–b) is made of a fine-grained siliceous rock (tentatively identified as quartzite). The dorsal ridges are sharp but both lateral edges are rounded, probably by use. The ground-edge tool (Fig. 16.8, 2a–c) is a fragment of an axe-head made from grey-brown chert. The core (Fig. 16.8, 4a–c) is an irregular fragment of yellowish-brown chert, exhibiting scars left by several flake removals.

The date of the lithic finds from Baška Voda harbour is uncertain, but the prismatic blades and the ground-edge tool can be paralleled in Neolithic or Chalcolithic sites along the east

Figure 16.7: Lithic artefacts from the seabed near Stipanac islet, central Dalmatia (After Brusić 1977: fig. 15)

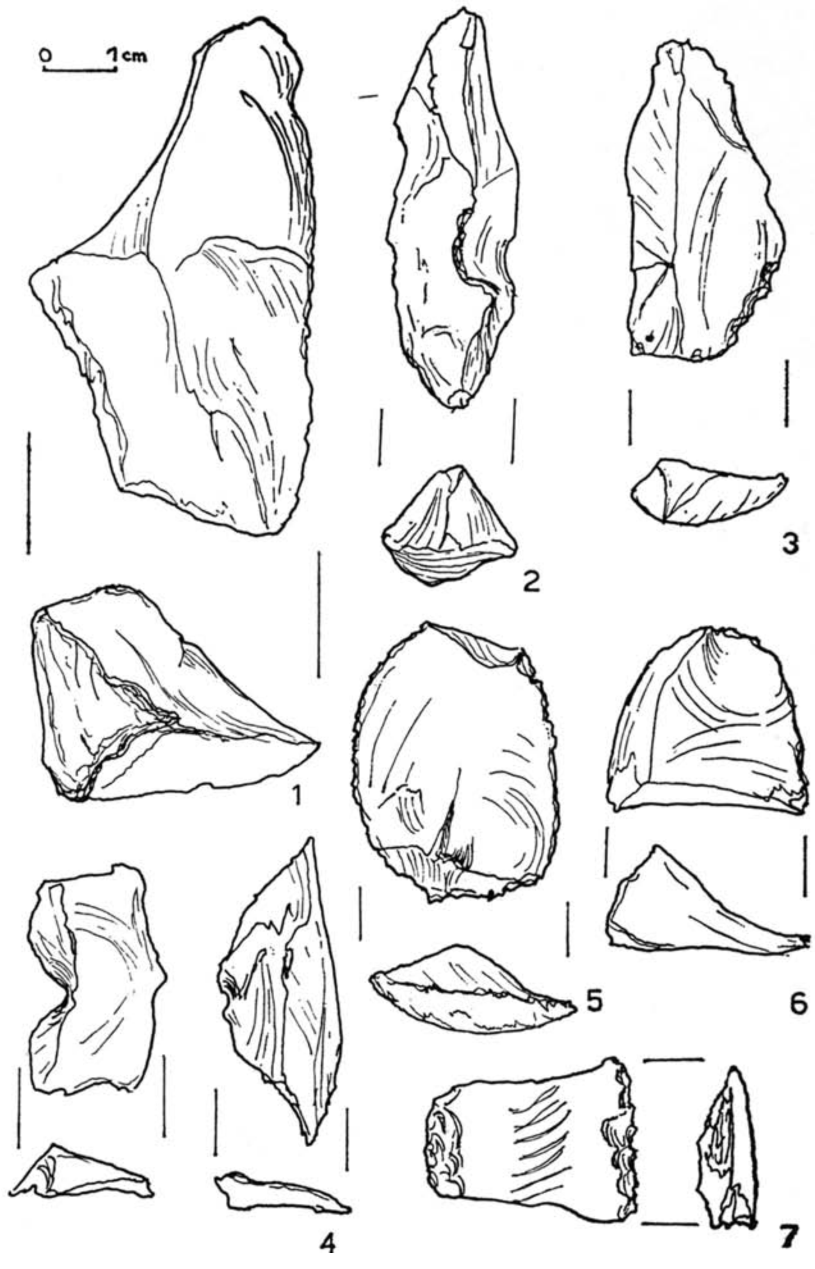


Figure 16.8: Lithic artefacts from Baška Voda. 1a–d retouched chert blade, 2a–c ground-edge tool fragment, 3a–b quartzite blade, 4a–c chert core (Photos: J. Benjamin)

Adriatic seaboard (cf. Mihovilić 1992; Čečuk and Radić 2005; Marijanović 2005; Brusić 2008).

Research in prospect

The preceding review of underwater prehistoric finds from the eastern Adriatic shows that most discoveries have been made in fairly shallow water (<5 m deep) close to shore. To a large extent this reflects circumstances of discovery. The finds in Veruda Bay and Baška Voda were accidental discoveries during harbour construction or operations, while those in Zambratija Cove and Veštar Bay were made during underwater fieldwork that was directed initially at maritime features or deliberately focused on the nearshore zone. What little evidence is available pertaining to the age of the finds suggests most belong to the time range from the Late Neolithic to the Early Bronze Age.

A growing body of evidence shows that the pattern of sea-level change in the Adriatic over the past 10,000 years has resulted from the interplay of eustatic, glacio-hydro-isostatic and tectonic factors, with isostatic and tectonic effects being variable across the region. Consequently, sea-level curves constructed for different parts of the coastline differ in detail (Lambeck *et al.* 2004). The sea-level data for the eastern Adriatic from Trieste Bay to Dalmatia (Antonioli *et al.* 2007; Faivre *et al.*, in press) suggest that relative sea level rose from about -10 m to -4 m during the Late Neolithic to Early Bronze Age, *c.* 5000–1800 cal BC (Fig. 16.9). This should be treated as a rough estimation, since the tectonic contribution to relative sea-level change may not have been uniform along the northeast Adriatic coast, or through time.

Prehistoric people would have located their settlements *above* the contemporaneous sea level – at elevations beyond the reach of storm waves, at least. In sheltered locations along the east Adriatic coast, the difference in height between mean sea level and shore-related settlements could have been as little as 1.5 m. Taking this into consideration, the depths at which known or suspected Late Neolithic–EBA sites have been found are consistent with the sea-level estimates.

Underwater archaeology and the 'neolithization' of the eastern Adriatic

The Adriatic rim is acknowledged to have been an important conduit in the spread of farming through the Mediterranean and into neighbouring regions of Europe, but *how* and *when* this agricultural expansion occurred is contentious. The scarcity of Late Mesolithic sites in the region, and the radiocarbon gap that has been observed in some caves sites between the Late Mesolithic and Early Neolithic (cf. Biagi

et al. 1993; Mlekuž *et al*. 2008), have led some authors to suggest that demographic expansion of farming populations from the Aegean or southern Balkans was the dominant mechanism, with adoption of agricultural practices by local (Mesolithic) hunter-gatherers playing only a minor role. A popular theory envisages pioneer leapfrog colonization along the coast and subsequent infiltration of the hinterland (Forenbaher and Miracle 2005).

Current ideas about the origins of the Neolithic of the eastern Adriatic littoral inevitably derive from land-based research. However, the spread of farming through the region took place when sea level was significantly lower than today; hence the coastal margins of the landscape occupied by the first farmers and their Mesolithic predecessors are now largely submerged. Any detailed investigation of these submerged landscapes requires underwater exploration, and there are two important questions with a critical bearing on current perceptions of the transition to farming in the Adriatic region, which will only be adequately addressed through underwater archaeology:

1. Were Late Mesolithic and Early Neolithic populations concentrated along the now submerged coastline?
2. What role did seafaring and coastal resources play in the lives of the last hunter-gatherers and first farmers of the region?

Establishing research priorities: where to look?

The critical period is between 7000 and 5500 cal BC. Sites with Impressed Ware pottery and evidence of stockraising and/or cultivation are found in northwest Greece and western Albania before 6000 cal BC (Sordinas 1967, 1969; Schuldenrein 1998). Permanent farming settlements were established in the Zadar region of Croatia by 5900 cal BC (Moore *et al*. 2007, in press), although Neolithic sites are not known from the Trieste Bay area at the head of the Adriatic before *c*. 5600 cal BC (Biagi *et al*. 2008; Mlekuž *et al*. 2008).

Data for the northeast Adriatic (Fig. 16.9) suggest that relative sea level rose from *c*. -27 to -13.5 m between 7000 and 5500 cal BC. This serves as a rough guide to the possible locations of shore-related sites belonging to the Final Mesolithic to Early Neolithic time range, and provides a benchmark for future underwater surveys. Such depths are accessible to archaeological divers using standard scuba equipment and compressed air.

Post-transgression sedimentation will also impact on the prospects for underwater site discovery. Rivers draining the Trieste Flysch, which comprises interbedded sandstones and marlstones of Eocene age, have deposited large amounts of sediment in the northern Adriatic basin and, locally, along the northern coast of Istria, sedimentation rates during the Holocene have been quite high. The average rate of sediment accumulation in Piran Bay has been estimated at 3 mm/year (Ogrinc *et al*. 2005) and similar rates may apply in the inner bays of Koper and Trieste. It follows that any shore-related sites in these areas dating to the

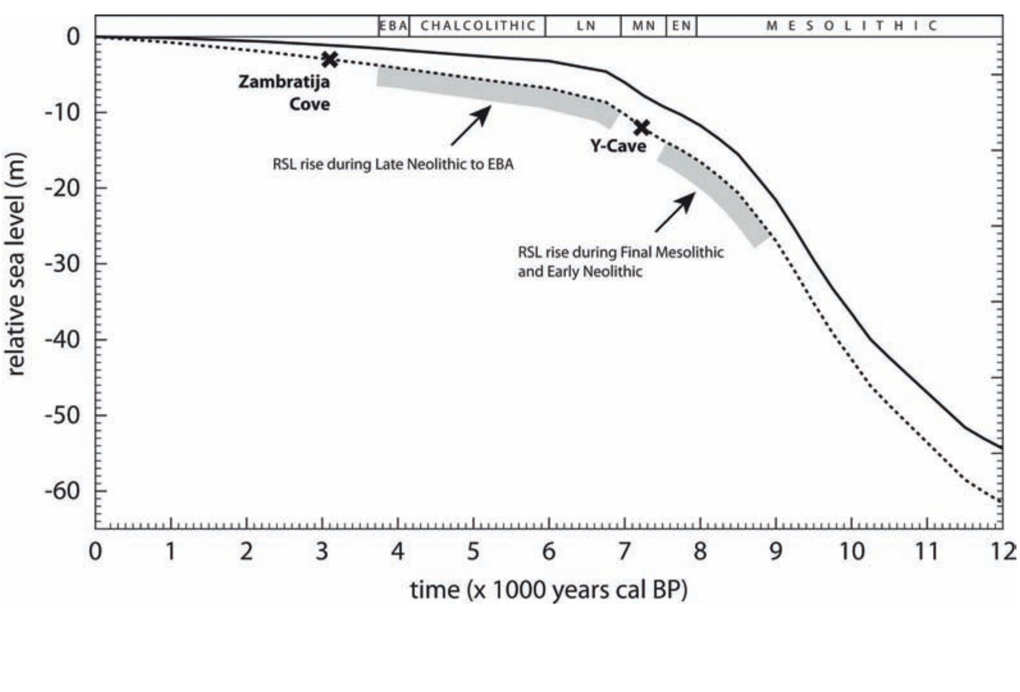


Figure 16.9: Predicted Holocene sea-level curve for Brijuni, northwest Croatia, in relation to the regional archaeological chronology. The solid line represents the eustatic change (After Antonioli et al. *2007). The dashed line is 'corrected' for tectonic subsidence averaging 0.6 mm/year, as estimated by Faivre* et al. *(in press) for the period 4–2 cal ka BP. EN Early Neolithic, MN Middle Neolithic, FN Final Neolithic, EBA Early Bronze Age, RSL relative sea-level. The altitudinal positions of the submerged Zambratija prehistoric site and Y-Cave are marked on the 'corrected' curve (Drawing: C. Bonsall)*

Mesolithic and Neolithic might be quite deeply buried.

South of Piran, however, along the Istrian and Dalmatian coasts, which are underlain by mainly carbonate rocks, sedimentation rates are generally much lower. It follows that the prospects for identifying archaeological finds or features on or just below the seabed are significantly better – it is hardly a coincidence that nearly all the prehistoric underwater finds to date have come from this part of the Adriatic.

Focus on the Zadar Archipelago

Any study of a submerged landscape should be preceded by familiarization with the geology and geomorphology of the region, together with a review of the existing archaeological and ethnographic data (for discussion, see Benjamin 2010).

The region between Zadar and Šibenik on the Dalmatian mainland has some important Stone Age sites (Chapman *et al*. 1996; Forenbaher and Miracle 2005; Komšo 2006). The Zadar archipelago with its hundreds of islands and islets created by the post-glacial marine transgression, therefore, seems an obvious place to begin the search for submerged shore-related sites belonging to the Mesolithic–Neolithic transition period.

At 45 km long and 124 km^2 in area, Dugi Otok (*Long Island*) is one of the larger islands in the archipelago. During the Last Glacial Maximum *c*. 20 ka BP, when sea level stood at *c*. -120 m (Fairbanks 1989; Blanchon and Shaw 1995), Dugi Otok was a ridge of high ground at the eastern edge of the now submerged Adriatic Plain. It became an island *c*. 12,000 BP/11,900 cal BC during the post-glacial marine transgression, evolving into its present form as sea level continued to rise during the Holocene. The island has not been intensively researched archaeologically, but land-based reconnaissance surveys mainly in the 1960s and 1970s produced archaeological finds of various periods, some claimed to date back to the Palaeolithic (Batović 1993). A small test excavation in Vlakno Cave uncovered evidence for the exploitation of marine resources (shellfish, crab, fish and octopus) during the Early Mesolithic, *c*. 10,000–9000 cal BC (Brusić 2005; Komšo 2006).

Dugi Otok is a promising target for underwater survey, because it has:

1. A settlement record extending back more than 11,000 years.
2. A karstic landscape rich in caves, including several known undersea caves.
3. A coastline with localized low wave energy environments (straits and protected embayments) and generally low seabed sedimentation rates, which increase the likelihood of underwater archaeological preservation and discovery.
4. A productive marine environment that has been exploited since at least the beginning of the Holocene.

Of the undersea caves recorded around the island, Y-Cave near Brbišica Cove (Fig. 16.10) is the best documented. Geological divers conducted a survey of the cave, noting its potential for prehistoric human habitation (Juračić *et al*. 2002). The cave entrance is *c*. 6 m high, and the presence of speleothems (calcium carbonate deposits formed by the action of water) suggests the former existence of a freshwater spring within the cave. Fine sediments cover the cave floor, which suggests minimal disturbance by wave and current action; and there is an absence of rock debris that could impede archaeological investigation. Moreover, the orientation of the main passage is similar to that of nearby Vlakno Cave (see above). Given its depth (12 m) below sea level, Y-Cave is unlikely to have been transgressed until after 5500 cal BC, and so would have been available for human use during the Mesolithic and, possibly, well into the Neolithic.

Prehistoric peoples often made use of caves for economic or ritual purposes whilst living in open-air settlements (for discussion, see Tolan-Smith and Bonsall 1997). Any study of the submerged prehistory of Dugi Otok, therefore, needs to include systematic surveys of palaeotopographic features within protected embayments, straits, and around river mouths

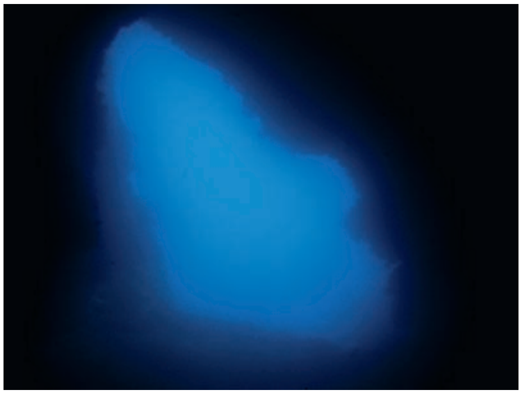


Figure 16.10: The 'daylight zone' inside Y-Cave, Dugi Otok. The cave entrance is c. *6 m high. Submerged sea caves are abundant along the Dalmatian coast and represent a potentially important archaeological resource (Photo: J. Benjamin)*

Figure 16.11: Southeast-facing oblique satellite image showing the sheltered environments of Telašćica Inlet on Dugi Otok. Left: generalized bathymetry. The inlet is approximately 8 km long (Image © Google Earth)

and promontories where open-air residential sites, fishing camps, and fixed installations might have been located prior to submergence.

Telašćica is a large inlet at the southeast end of Dugi Otok, with numerous small bays, headlands, and islands (Fig. 16.11). Sea-level rise data suggest the inlet came into being in the Late Glacial and evolved through the Holocene as sea level continued to rise. The inlet has several characteristics that make it attractive for underwater archaeological exploration aimed at identifying submerged Mesolithic and Neolithic sites. These include: (i) evolving shorelines and sheltered marine environments that would have been accessible from the Upper Palaeolithic onwards; (ii) localized areas of fertile soils in close proximity to the shoreline; (iii) a known concentration of prehistoric sites at the head of the inlet (cf. Batović 1993); (iv) numerous low wave energy environments with high archaeological preservation potential; and (v) water depths that are easily accessible to archaeological divers.

Research strategy and methodology

A systematic study of the submerged prehistory of Dugi Otok would include the following elements (cf. Benjamin 2010; see also Lübke *et al.* and Westley *et al.*, this volume):

- review and assessment of previous research (desk study);
- familiarization with the regional geology, geomorphology, and hydrology;
- ethnographic survey;
- mapping of the palaeolandscape and evaluating its archaeological potential;
- palaeoenvironmental sampling;
- archaeological testing.

Several authors have stressed the importance of using underwater archaeology to supplement the (often eroded and weathered) record from adjacent terrestrial sites (e.g. Wilkinson and Murphy 1986). It follows that an integrated approach is desirable, in which the submerged landscape research is preceded by an assessment of the land-based evidence. Field inspection of adjacent terrestrial sites, including topographic surveys where these have not already been done, might aid interpretation of the submerged landscape. On Dugi Otok, for example, an assessment of the topographic setting and archaeological evidence from Vlakno Cave should precede any archaeological investigation of the submerged Y-Cave.

Research by Fischer (1993, 1995) in the western Baltic has demonstrated the value of *ethnographic research* in helping to identify submerged prehistoric sites (for further

discussion see Benjamin 2010). Ethnographic interviews with local fisherman on Dugi Otok, especially those elderly residents who practised traditional fishing methods before electricity and refrigeration were introduced to the island around 1960, are an essential prerequisite for any study of the submerged prehistory of the island. The information gained regarding the species of fish and shellfish targeted, the capture and processing methods employed, and the locations where particular activities were carried out can inform the interpretation of previous archaeological finds as well as underwater survey strategy.

Mapping of submerged landscapes can be done at different scales and resolutions, with variable cost implications. One approach would be to use the available (consumer grade) bathymetric charts for the waters around Dugi Otok to provide basic, low-resolution data on the topography of the broader palaeolandscape, followed by higher resolution studies of smaller areas like Telašćica inlet and the environs of Y-cave, with the standard bathymetric data being supplemented by more sophisticated sonar or marine-based LiDAR surveys. Bathymetric data alone, however, can fail to detect small-scale landscape features, such as palaeochannels, especially where these are infilled with marine sediments. Therefore, we would advocate the use of sub-bottom profiling (where cost-effective) and/or corer/auger sampling in order to provide geotechnical data and 'fine-tune' palaeotopographic reconstructions. The resulting palaeolandscape record could then be used to create a map of 'archaeological potential' highlighting topographic features that may have been used by prehistoric people for settlement or subsistence-related activities, combined with an assessment of the potential for archaeological preservation.

Once the baseline data have been collected and analyzed, focused sampling for palaeoenvironmental and archaeological evidence would be conducted in high-priority locations. Palaeoenvironmental sampling would be aimed at identifying biogenic or fossiliferous deposits (e.g. shell beds), and collecting samples for radiocarbon and environmental analysis. In caves, augering can also help to determine the extent of roof collapse, the likelihood of archaeological discovery based on sedimentation type, and the presence of deposits likely to contain cultural materials. The data recovered may also contribute to regional reconstructions of sea-level change and coastal environments. Archaeological testing, which is partly dependent on water depth and time constraints associated with scuba diving, may encompass a variety of standard underwater methods ranging from simple hand fanning (where seabed sediments are thin) to (manual or dredge-assisted) test-pitting.

Conclusions

Large areas around the Adriatic Basin that were once settled by prehistoric populations have been submerged as a result of sea-level rise since the Last Glacial Maximum. This chapter has reviewed the current state of research into the submerged prehistory of the eastern Adriatic and outlined the potential for larger-scale studies aimed at addressing major research questions.

At least eight submerged sites or localities with prehistoric artefacts have been reported along the east Adriatic coast between Piran in Slovenia and Makarska in Croatia. In most cases the finds were made close to shore in water less than 5 m deep. Several sites contained pottery and stone artefacts that indicate a Late Neolithic to Bronze Age date, and it is likely the sites were located on or near the coast at the time of their occupation. One site, Zambratija Cove in Istria, has well-preserved structural remains and organic materials that offer the possibility of high-resolution radiocarbon (and perhaps dendrochonological) dating. In turn, precise dating of (potentially) shore-related sites like Zambratija, would contribute to a better understanding of relative sea-level change and shoreline displacement during the Holocene.

Shore-related sites belonging to earlier prehistoric periods would lie at greater sea depths. On present evidence relative sea level rose from *c.* -27 to -13.5 m during the period between 7000 and 5500 cal BC, corresponding to the Final Mesolithic and Early Neolithic, and such depths are accessible with standard scuba equipment and compressed air. The transition from Mesolithic to Neolithic is a crucial but under-researched period in the prehistory of the eastern Adriatic, and there are important issues relating to the origins and spread of farming in the region that can only be addressed through submerged cultural landscape studies. We have presented a research design for one such study focused on Dugi Otok, a large island in the outer Zadar archipelago in northern Dalmatia.

By drawing attention to extant underwater prehistoric finds and the prospects for more extensive and systematic underwater research and site discovery along the Istrian and Dalmatian coasts, we hope to have demonstrated that the eastern Adriatic has considerable potential for the survival and investigation of submerged cultural landscapes. We suggest the archaeological exploration of these palaeolandscapes should be given a high priority, since it could have a profound impact on our understanding of the prehistory of the Adriatic basin and, by extension, the wider Mediterranean.

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17

The Pavlopetri Underwater Archaeology Project: investigating an ancient submerged town

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Pavlopetri, off the coast of Laconia, Greece, is a submerged prehistoric town, which consists of intact building foundations, courtyards, streets, graves, and rock-cut tombs. New underwater research in 2009 consisted of detailed underwater survey of the structural remains (using a robotic total station and sector-scan sonar technology) alongside sampling of the artefactual material across the site. In addition to the digital recording of the 30,000 m^2 of previously known buildings, over 9000 m^2 of new buildings were discovered in 2009 including a large rectangular hall and a street lined with buildings. The ceramics recovered confirm the Mycenaean occupation of the site but also reveal occupation as early as 3500 BC making Pavlopetri, at over 5000 years old, the oldest known submerged town in world.

Keywords: submerged settlement, underwater survey, sector-scan sonar, Bronze Age Greece, Mycenaean, processes of submergence

Introduction

In 2009 the University of Nottingham, through a British School at Athens permit, began a five-year collaborative project with the Ephorate of Underwater Antiquities of the Hellenic Ministry of Culture and Tourism and the Hellenic Centre for Marine Research (H.C.M.R.) to outline the history and development of the submerged prehistoric town at Pavlopetri, which lies just off the Pounta shore, opposite the island of Elaphonisos, in southern Laconia (Fig. 17.1). Through detailed digital underwater archaeological survey (2009–2010) and targeted underwater excavations (2011–2013), the Pavlopetri Underwater Archaeology Project aims to establish when the site was occupied, what it was used for and, through a systematic study of the geomorphology of the area, how the prehistoric town and the Strait of Elaphonisos became submerged. More broadly, the project aims to shed light on the importance of Pavlopetri

Figure 17.1: Location of the submerged ancient town of Pavlopetri

in terms of maritime control over the Laconian gulf and southern Peloponnese and the role of the settlement in maritime trade and the regulation of trade networks in the Aegean and beyond.

Project background

Submerged archaeological remains were first identified off the coast of southeastern Laconia in the west end of the Bay of Vatika in 1904 by the geologist Fokion Negris (1904: 362–3) but the importance of his discovery was not widely recognized at the time. The remains were re-discovered in 1967 by Nicholas Flemming who identified and confirmed the existence of a prehistoric town at the location (Flemming 1968a, 1968b).

In 1968 a team from the University of Cambridge surveyed the submerged remains over six weeks using a fixed grid system and hand tapes (Harding *et al*. 1969; Harding 1970). They produced a plan of a prehistoric town covering an area of *c*. 300 × 100 m, lying in 1–4 m of water. At least 15 separate building complexes (consisting of a series of rooms), courtyards, streets, two chamber tombs, and 37 cist graves were identified. The underwater site was seen to continue southward on Pavlopetri Island on top of which the remains of walls and archaeological material were still visible. On the Pounta shore they recorded an extensive cemetery of at least 60 rock-cut graves that have been provisionally dated on the basis of their architectural plans to the Early Helladic (EH) period (3000–2000 BC). The 1968 project recovered a small amount of surface finds from the seabed (mainly pottery, but also obsidian and chert blades and a bronze figurine), which suggested a date range from the Early to the Late Bronze Age (*c*. 2800–1180 BC) (Harding *et al*. 1969: 132–7). On the basis of the higher frequency of Late Helladic ceramics, however, the submerged buildings at Pavlopetri were considered to date mainly from the Mycenaean period (1650–1180 BC) (Harding *et al*. 1969: 139). Evidence for the later occupation or use of the site has been provided by the occurrence of a fair quantity of later pottery, namely a fragmentary Hellenistic cooking-pot, black-glazed sherds and fragments of ribbed ware of Roman date, and sherds with wavy grooved decoration of the late 6th or 7th century AD (Harding *et al*. 1969: 137–8). After the 1968 survey no further research was carried out and the site was placed under the care and protection of the Greek State.

In 2007 a postdoctoral researcher in the Department of Archaeology at the University of Nottingham, Chrysanthi Gallou, began a reassessment of the 1968 finds from Pavlopetri as part of her wider research on prehistoric Laconia. She began discussions with Jon Henderson about the possibility of returning to the site to carry out further archaeological work. The Pavlopetri Underwater Archaeology Project began to take shape when, together with Nicholas Flemming, the two visited the site in 2008, exactly 40 years after the original Cambridge survey, and discovered its remains were still well preserved on the sea floor. Following this trip, a five-year plan of survey and excavation was conceived in collaboration with the Ephoreia of Underwater Antiquities of the Hellenic Ministry of Culture and Tourism.

2009 survey season

Over two-and-a-half weeks from May to June 2009, a joint Greek and British team of archaeological divers and archaeologists under the general direction of Elias Spondylis and Jon Henderson began the essential first stage of the project: to accurately record, using modern digital techniques, the surviving architectural remains on the site as well as recover and study a range of archaeological surface finds from across the site. Thus, fieldwork consisted of detailed digital underwater survey of the structural remains (using shore-based total stations and revolutionary sector-scan sonar technology) alongside sampling of the artefactual material across the site.

Survey techniques

In 2009 the project employed two cutting-edge methods of underwater survey. First, points were taken using a shore-based robotic total station equipped with data-logging software and a pen-based computer. The total station was used to target divers taking points in the water using a detail pole equipped with a prism. These points were displayed on the computer screen as they were taken, which is particularly advantageous for underwater survey; it means that grids and tapes do not have to be set up underwater and divers can position themselves at any point on the site at any given time (Henderson and Burgess 1996). The key difficulty with this technique is ensuring that

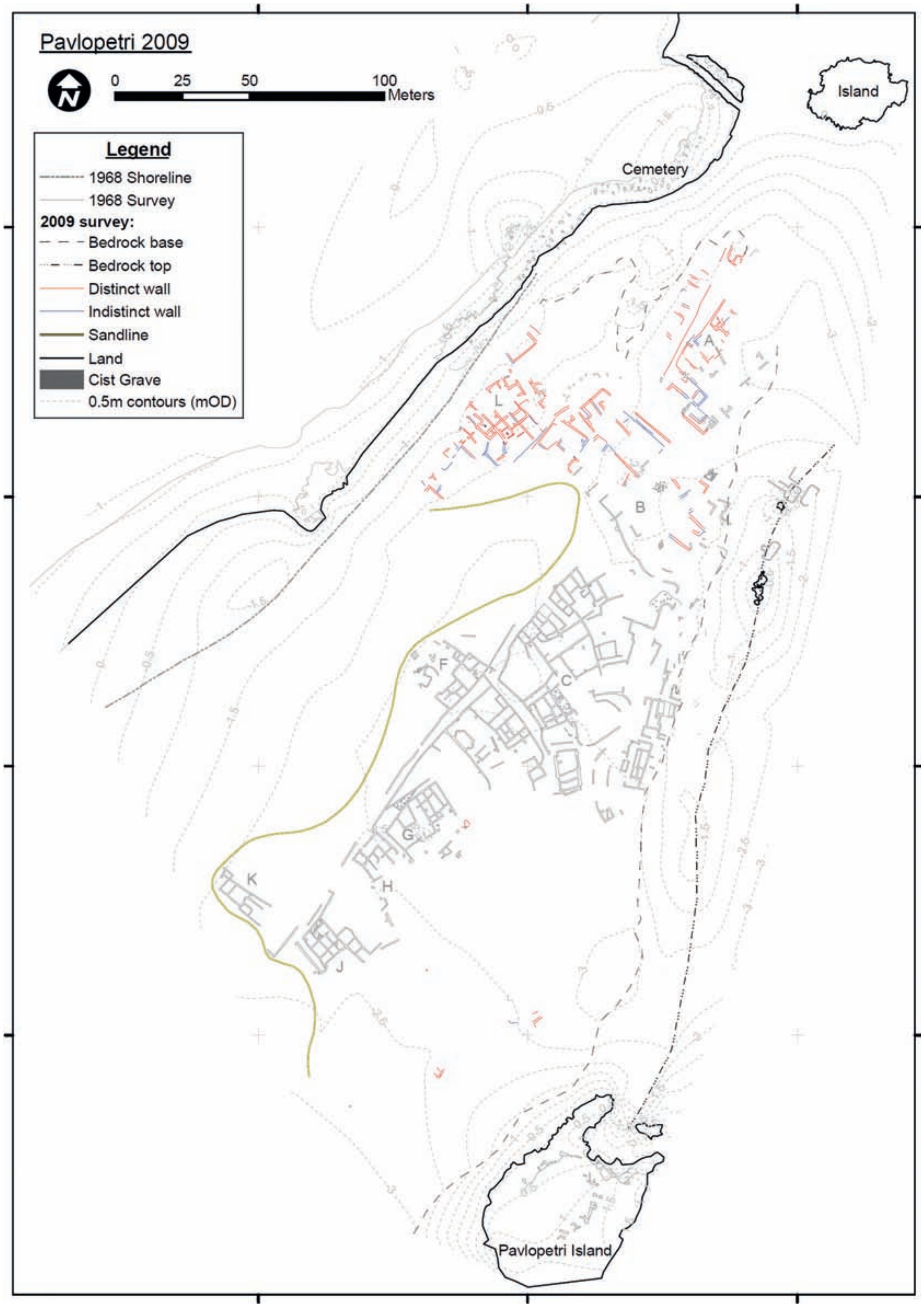

Figure 17.2: 2009 total station contour survey of Pavlopetri

the detail pole in the water remains vertical over the point to be taken underwater. A lightweight aluminium detail pole was designed for the project, which could be extended from 1–5 m in height. The pole has bubble levels attached throughout its length, which can be read by divers in the water. The pole is used in the water by four divers, two working underwater and two snorkelling on the surface. The first diver is present at the bottom of the pole to place it on the point to be

taken, while the second diver decides on the next point to be taken. Using a series of signals the divers underwater and the surveyor on shore can communicate with one another quite effectively through the snorkellers on the surface. As well as facilitating communications, the snorkellers are responsible for ensuring the staff is vertical – looking at the bubble levels, one holds the staff and ensures it is in line with the total station on the shore while the other snorkeller, positioned to the side of the staff, ensures there is no tilting away from or toward the shore. Using the bubble levels the maximum error (where only half the bubble was inside the centre circle of the bubble level) was found to be less than 5 cm at a full pole extension of 5 m. The most common staff height was 3.5 m ensuring errors of less than 3.5 cm for the majority of the points taken. The accuracy of the instrument was tested twice a day on known reference points on the site. The shallow nature of the site and its proximity to the shore allowed the survey to be carried out to similar levels of accuracy and speed as achieved on terrestrial sites (Fig. 17.2).

In addition to the total station work, trial survey was carried out using a Kongsberg–Mesotech MS 1000 sector-scan sonar under the direction of Nautilus Marine Group International – a company that uses this new technology in the commercial sector to carry out underwater inspections and surveys of bridges, dams, ports, and harbours. The sector-scan sonar is a device that generates high quality metrically accurate images of the underwater environment, and as such has great potential for underwater archaeological survey.

Side-scan sonar has been traditionally used in maritime archaeology to locate archaeological sites and map areas of seabed. Specifications and models of side-scan sonar vary but all must either be hull-mounted or towed by a vessel. For side-scan to operate the survey vessel must be in constant motion through the water which makes it difficult to use in confined areas such as Pavlopetri and, equally, side-scan units usually cannot be deployed in shallow water (<4 m). Since the sector-scan sonar operates from a fixed position on the seabed it is better suited to planning individual sites in detail as the location of areas being scanned can be more tightly controlled. It is relatively simple to redeploy the sector-scan sonar over known points, to revisit and rescan important areas, and as a result build up a more detailed record of a site over time. The sector-scan sonar can be deployed in depths of up to 3000 m but, crucially for the work at Pavlopetri, it can also be used in extremely shallow water – as long as the sonar head is immersed it will function. It can thus operate in depths of water as shallow as 0.5 m and obtain accurate data.

Figure 17.3: The Kongsberg MS 1000 sector-scanner as it is deployed underwater. The device is secured within a protective tripod, which is lowered onto the seabed

The system consists of a sonar operating computer housed on a boat, which directly connects through a high tensile weight cable to a sonar head unit hung from a movable stainless steel tripod in the water (Fig. 17.3). The in-water sonar unit can be accurately positioned on the seabed using GPS position fixing to within ±50 mm. The sonar head transmits a very narrow acoustic beam, which is swept vertically so that the returning echoes indicate the distance and angle of depression to the many reflectors. Since the position of the transmitter is fixed, it can obtain higher levels of resolution of acoustic data than conventional side-scan or echo sounder units. The sonar head incorporates a stepped motor that allows full 360° scan coverage of the area surrounding the unit, with successive high-resolution pulses. A high-frequency (675 KHz) acoustic ping is transmitted from the sonar head and the system waits to receive the echoed returns. Once the return is received the motor steps the transducer in parts of a degree to a new azimuth

angle, and the process is repeated. This is done until a full 360° circular sweep is carried out. The scan radius is set by the operator and may range in distance from 5 m to 1000 m. It normally takes between two and five minutes to complete an individual scan once the head is deployed on the seabed. As the distance from the scanning head increases, the quality of the image decreases.

Typical scan radii used for the submerged structures at Pavlopetri ranged from 100 m scans of building complexes (covering a total seafloor area of 31,000 m^2) down to very high resolution 5 m scans of areas of importance such as cist graves (Fig. 17.4). Image resolution is improved by moving the sonar head closer to the feature being imaged. In terms of recording individual buildings, scan radii between 15 m and 30 m were found to be most effective producing measured scans in which the individual stones used in the construction of the walls were visible. In much the same way as a terrestrial laser-scanner cannot see through solid objects, the sector-scan will produce an acoustic 'shadow' behind upstanding features that it images. To overcome the problems of acoustic 'shadow', the in-water sonar unit is redeployed at additional locations around

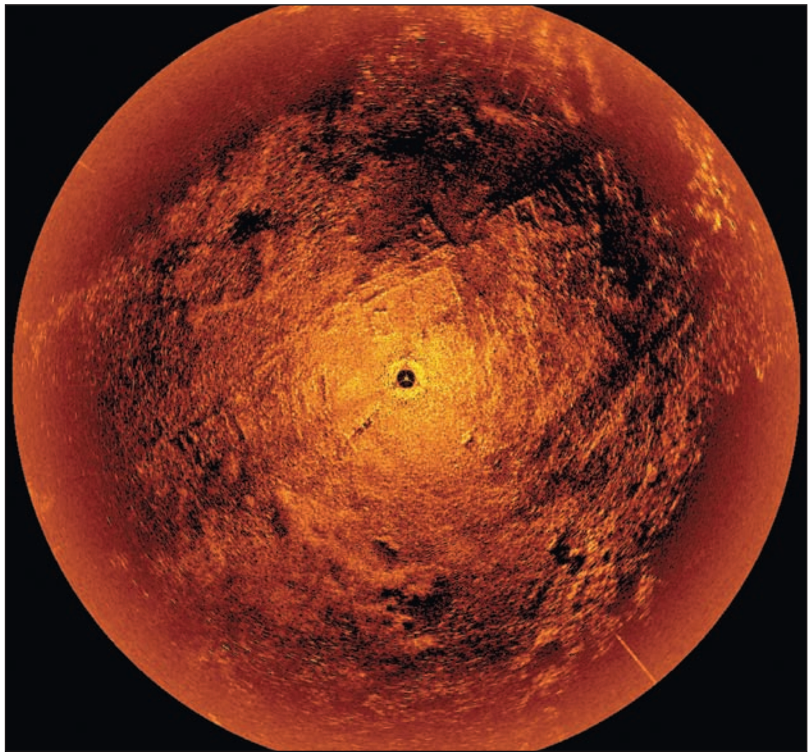

Figure 17.4: 100 m radius sector-scan of Pavlopetri. Scanner is located 10 m to the south of Building IX in Area C

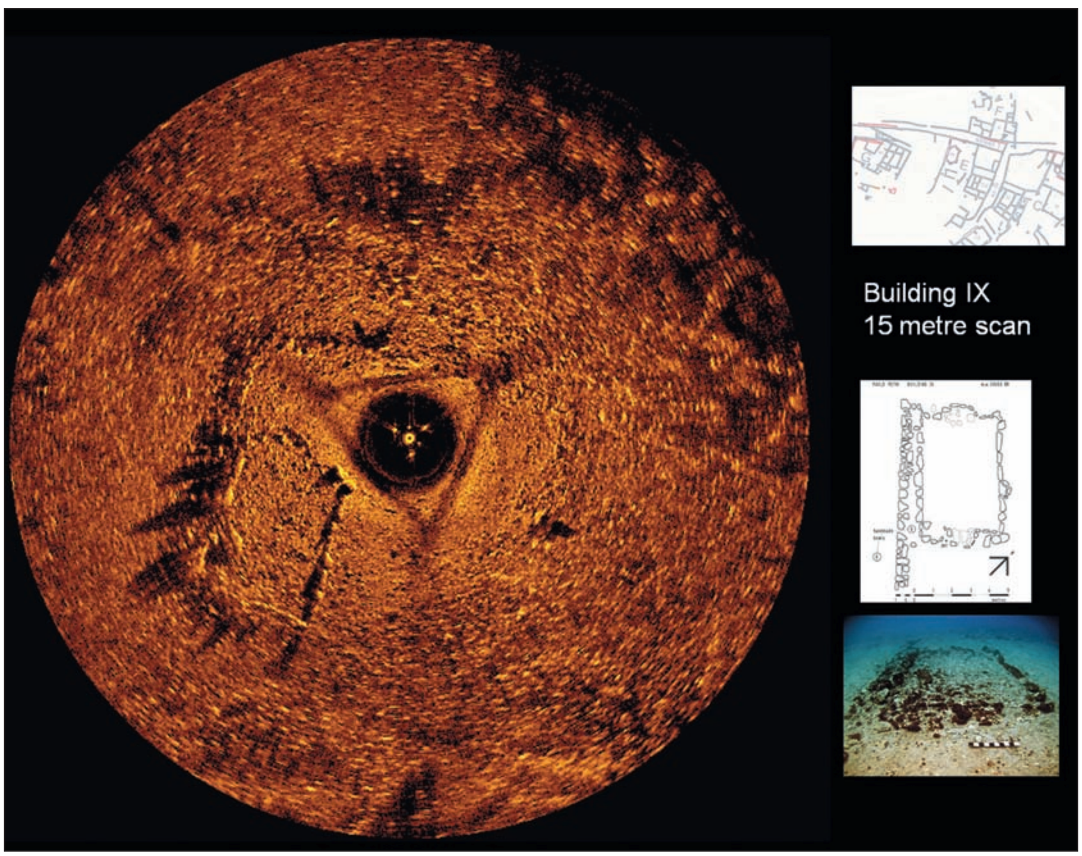

Figure 17.5: 15 m radius scan of Building IX, Area C

structures to map the areas in 'shadow'. A mosaic can then be created of all the scans taken of a given area to eliminate shadows and produce a highly detailed and accurate composite master image. In order to fully image individual buildings at Pavlopetri at least one scan from within a building was needed, backed up by at least four separate scan locations around the perimeter of the building to eliminate areas of acoustic 'shadow' (Fig. 17.5).

The ability to visualize submerged archaeological features and produce measured scans of them in a matter of minutes has obvious advantages to the practice of underwater archaeology. The MS 1000 sector-scan sonar provides instantaneous high-resolution seafloor scans that consist of three-dimensional point cloud data comparable to that produced by terrestrial laser scanners. Carrying out circular scans from known points fixed by GPS the whole site plan at Pavlopetri was mapped in a matter of days. All of the upstanding structural elements of the site – buildings, streets, courtyards, walls, and graves – were recorded in three dimensions alongside the topography of the seabed. The data produced by the sector-scan sonar can be manipulated in 3D environments to produce isometric images of the building complexes at Pavlopetri. Over the coming year the sector-scanning data will be combined with the total station data to produce accurate three-dimensional models of the site.

Discoveries

The visible architectural remains at Pavlopetri begin some 20 m from the shore at Pounta Beach and run over 300 m south out to Pavlopetri Island. They are bounded to the east by a bedrock ridge, running north to south, and to the west by extensive sand deposits and deeper water (no remains have been identified in water depths exceeding 3 m). Beyond Pavlopetri Island and the eastern rocky ridge the sea is deeper and no artificial constructions can be traced. Nothing to indicate the existence of artificial harbour constructions or jetties could be identified in 2009.

The town appears as a series of large spreads of stones indicating building complexes, amongst which a network of stone walls can be traced. The walls themselves are made of uncut aeolianite, sandstone and limestone blocks, and were built without mortar. They can survive up to three stones in height but the vast majority survive only one course high or are completely flush with the seabed. The submerged remains (buildings, streets, cist graves, and rock-cut tombs) recorded in 1968 can be clearly identified (Fig. 17.6) and survive more or less in the same condition as they were originally reported (though most of

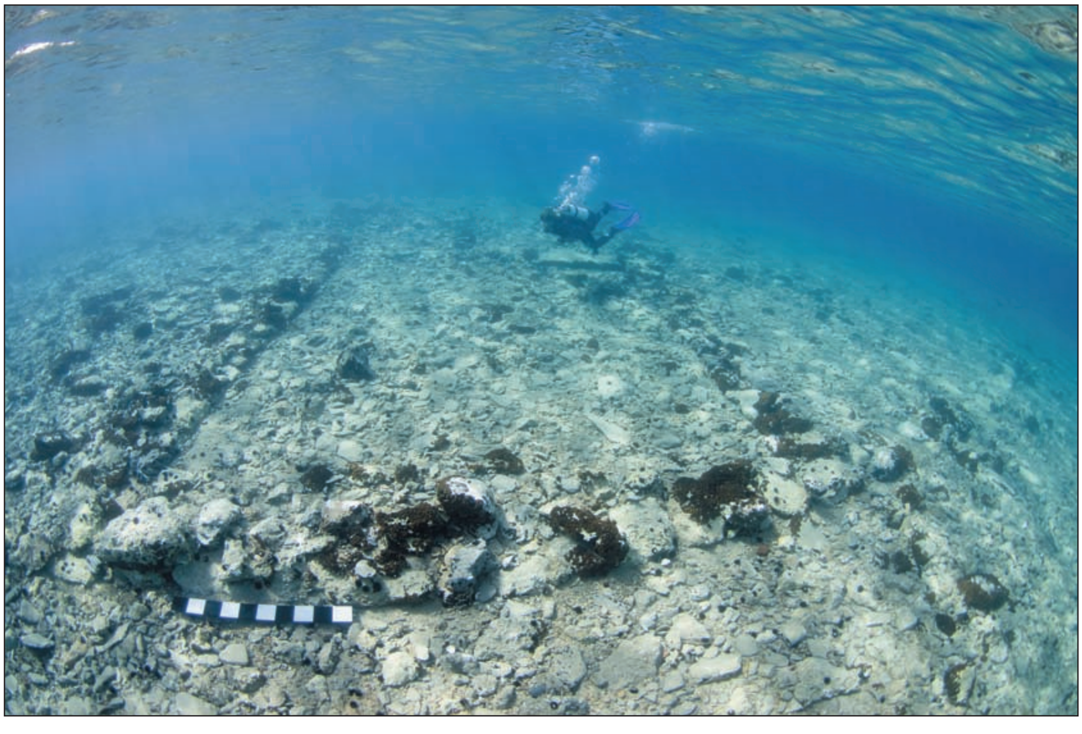

Figure 17.6: Diver over room in Building II, Area C

Figure 17.7: New areas uncovered in 2009

the cist graves seem to have been interfered with). The existence of the eastern rocky ridge has protected the remains from the full force of wave action over the years – where there are gaps in the ridge walls have either been completely eroded away, as seems to have happened near Pavlopetri Island, or they have been eroded almost flush with the seabed.

The accuracy of the survey plan produced in 1968 was checked and verified using the total station and sector-scan sonar. In addition to the recording of the 30,000 m^2 of buildings first identified in 1968, over 9000 m^2 of new structures were discovered coming out of the sand to the north of the original remains in 2009 (Fig. 17.7). It is likely that these remains had been covered by sand deposits in previous years, as they had not been seen by divers or swimmers visiting the site in 1967, 1968, or 2008. The suggestion that the buildings were recently exposed was borne out by the cleaner appearance of the stonework in the new areas compared to the older areas which feature well-established marine algal species and encrusting marine organisms (especially brown and black sponges and sea urchins). Changes in sand cover could be related to changes in the position and shape of the shoreline over time causing variability in wave action (cf. Galili and Rosen, this volume). Equally the map of the bathymetry and topography of the town and the eastern bedrock ridge that protects the site shows there are low gaps in the ridge where wave action would pass through and be diffracted and refracted round Pavlopetri Island itself, and the other high points. This would result in a focusing of wave energy at discontinuous points over the town and the adjacent beach, with a pattern of high and low energy determined by the recent wave direction. While this shifting pattern is not yet understood, the discoveries made in 2009 suggest that revisiting the site in future years and at different seasons may reveal further parts of the Bronze Age town, which are at present under thick beds of sand.

The newly discovered remains consist of an area of at least 25 conjoined square and rectilinear rooms (built of rough square limestone blocks as elsewhere on the site) starting some 10 m from the existing shoreline. A 40 m long street was also identified lined with rectilinear buildings with stone foundations. One square building, measuring *c*. 3 × 3 m, contains the remains of a central pillar-like structure comparable on first glance with pillar crypt rooms associated with palaces and villas on Minoan Crete (cf. McEnroe 1982). If this room were indeed a pillar crypt it would be the first example from the Greek mainland. Two new cist graves were discovered alongside what appears to be a Bronze Age *pithos* burial located in a corner of one of the newly discovered rooms.

One of the most important discoveries of the 2009 season was the identification and recording of a large trapezoidal building, measuring *c*. 34 m in length and 12–17 m in width. The structure contains at least three separate rooms and is comparable in layout to Early Bronze Age (EBA) buildings (cf. Shaw 1987; Darcque and Treuil 1990). Its large dimensions and its prominent position within the settlement certainly imply that it was a building of some importance.

The new discoveries, combined with the data from the 1968 survey, suggest a town of greater importance than previously estimated. The visible remains now cover almost 4 ha and consist of intact stone building foundations, monumental structures, courtyards, streets, cist graves, and rock-cut tombs. Given that there are probably still many more buildings hidden under the sand, and that scattered fragments of walling are found out toward Pavlopetri Island suggesting that the town originally extended as a fully built-up area as far as the island, the original size of the settlement is likely to have been at least 8 ha. Given the lack of rubble from the site as a whole it is likely that the surviving walls represent the ground floor of the buildings with stone foundations built to around a metre in height and the upper sections constructed of mud brick and/or timber frames covered in plaster. Thus only the very base of the wall was stone, probably to prevent the foundations from being eroded away by rain and water running down the streets.

A non-random sample of diagnostic surface sherds was collected from across the full extent of site, including the newly discovered areas, in order to provide some insight into the length of occupation at the site. The ongoing study of the pottery sampled in 2009 (a total of 442 ceramic artefacts alongside an iron nail and an obsidian chip) provides the following statistical data: 3% Final Neolithic, 40% Early Bronze Age, 15% Middle Bronze Age, 25% Late Bronze Age, 3% Classical/Hellenistic, and 0.5% Roman/Byzantine. The remaining 13.5% of the pottery is provisionally characterized as 'Bronze Age'. The discovery of a group of sherds dates the original occupation of the site in the Final Neolithic

period. The Final Neolithic pottery shows affinities with examples from contemporary settlements and cave sites in Laconia, whereas the occupation of the site during this period corresponds well with the evidence from other sites in the vicinity of Pavlopetri (Waterhouse and Hope Simpson 1961: 145–6; Gallou 2008: 294) as well as cave sites in the Vatika region (Efstathiou-Manolakou 2009: 14–15).

An extensive range of EH *pithoi* and storage jars can be identified decorated with an impressive repertoire of rope- and finger-impressed patterns. In addition to the storage vessels (some with mat-impressed bases), the sampled pottery features the standard EBA shapes such as cups, sauceboats, conical saucers, askoi, portable hearths, and dishes. Significant for our understanding of the relations between Pavlopetri and the Aegean is the pottery that shows close links with the Cyclades, western Crete, and northeast Aegean (Henderson *et al.*, in press).

In contrast to the limited picture we have from the 1968 survey for the occupation of the site during the Middle Bronze Age, a fair amount of MH pottery was lifted in 2009 and includes locally produced wares and what appear to be a few imports, possibly from the nearby Minoan colony on Kythera. Of particular interest are the sherds from storage vessels that feature rope- and finger-impressed decoration with Middle and Late Minoan parallels (Christakis 2005).

The Late Bronze Age pottery is dated from the transitional MH/LH period until the collapse of the Mycenaean palaces. The collected sherds belong to drinking vessels, mainly kylikes and cups including a fragmentary Vapheio cup, storage vessels (amphorae and alabastra), and vessels for serving liquids (squat jugs, skyphoi, and kraters). A large number of sherds feature strong Late Minoan IB influence. The discovery of a clay strainer that can be provisionally dated to LM IB times is of particular interest. Part of a strainer of the same date, albeit of a different form, was discovered in 1968.

The site was most probably abandoned in post-palatial times and was re-occupied – to a much lesser extent – during the Classical and Hellenistic periods as suggested by a number of shattered skyphoi that can be securely dated to the 4th century BC, and body sherds and double-barrel handles dating to the 3rd century BC. The Late Antique pottery recovered both in 1968 and in 2009 could be associated with the limited re-occupation of the site and the involvement of the local community in the trade of the local *poros* stone, iron from the nearby ores at Ayios Elissaios, and the exploitation of beds of *Murex* (marine gastropod *Murex trunculus* or the banded dye-murex) for the production of purple dye.

The submergence of Pavlopetri

It is clear that the Bronze Age buildings foundations and pottery at Pavlopetri have been submerged by *c.* 4–5 m during the last 5000 years. The lowest building foundations found so far are at almost 3 m depth, and these were presumably well clear of storm wave run-up in extreme winter storms, which would likely recur within a generation. Mean annual wave significant height (Hs) at Pavlopetri is 0.55 m (Watson 2008), and the 100-year return value of Hs is 1.0–1.5 m. Since the maximum wave height (Hmax) is of the order of twice Hs, waves of the order of 1.5–2.0 m could strike the shore at Pavlopetri at intervals of a few decades. The following discussion of the geomorphology of the site, and the geomorphological and tectonic changes that have occurred will be based on the two possible estimates of 4 m or 5 m vertical displacement until a more accurate assessment can be derived from the on-site data.

There are several questions about the development of the town in the Bronze Age, and its subsequent submergence, which depend upon an understanding of the geomorphology of the seabed and coast from the western entrance to the Channel between Elaphonisos and the mainland, round the seaward side of Pavlopetri Island, and several kilometres along the shore of the Bay of Vatika. These are:

1. The position of the shore at the time of first occupation of the town site.
2. The position of any shelter for ships, embayment, lagoon or harbour, which may have attracted settlement, and may have supported seafaring and trade.
3. The shape of the isthmus connecting Elaphonisos to the mainland at the time of settlement.
4. The rate of submergence and the evolution of the isthmus, leading to its final rupture and the creation of an unobstructed channel.
5. The possible construction of a causeway, or reinforcement of the isthmus, in the last stages of submergence or the erosion of unconsolidated alluvium.
6. Calculation of the most probable rate of submergence, and the effect of this on the

development of and final abandonment of the site.
7. The significance of modern movement of the sand banks overlying the submerged ruins.

The eustatic rise of sea level after the Last Glacial Maximum terminated at *c*. 6800–5700 cal BP (Flemming 1978; Lambeck and Chappell 2001; Lambeck 2004; Lambeck *et al.* 2004) and regional sea level in the Mediterranean has fluctuated by less than 0.5–1.0 m since that date (Flemming and Webb 1986; Morhange *et al.* 2006; Marriner and Morhange 2007). Thus the submergence of Pavlopetri is due largely to tectonic factors associated with the plate convergence and subduction in the Cretan Arc and the related local and regional faulting. It is not possible at present to attribute the subsidence to a particular fault or seismic event, but the frequent occurrence of seismicity in the area is well documented (Angelier *et al.* 1982; Pirazzoli *et al.* 1982; Stiros 2009). The archaeological site of Plitra, 26 km to the north of Pavlopetri, is also submerged by several metres (Flemming 1973; Hadjidaki *et al.* 1980) while Antikythera 80 km to the south is uplifted (Flemming 1973; Pirazzoli *et al.* 1982). While the process of submergence, and its nature in terms of continuous or successive steps of subsidence is not yet established, the average rate is of the order of 0.8–1.0 m per thousand years.

In 2009 submerged strips of beach-rock were identified and drawn by divers in Vatika Bay within 200 m of the eastern edge of the site at a depth of 3.5–4.0 m, and aerial photographs show two or more parallel dark strips on the seabed in the same location. These strips of beach-rock provide the potential to measure the position and depth of the shoreline at precise dates. The shoreline at 4–5 m depth will be established by an accurate survey of the bathymetry in this depth range, taking account of the thickness of modern marine sediments.

The shape and position of the aeolianite ridges, which form the bedrock of the cemetery on land, and the protective ridge to the seaward side of the Bronze Age town suggest an embayment that may have enclosed a harbour. This impression is misleading, since, if the sea were 4–5 m lower than at present, the depression would have been completely dry land, and the town itself clearly occupied most of this space. It is, however, unlikely that there was no local shelter for sea-going vessels. The location of the Bronze Age town is at the point of minimum wave action in Vatika Bay (Watson 2008), and other sites are known where ships were dragged up onto the beach for protection (e.g. Bronze Age sites Ashkelon and Tel Qatif in Israel [Flemming *et al.* 1977]), but there is still a need to identify conclusively whether there was an enclosed sheltered basin or not. Single-beam echo-sounding and multibeam surveys of the seabed west of the town, between Pavlopetri and into the Channel, will reveal whether there was an inlet, lagoon, or basin there that would have provided secure protection for vessels without beaching.

Classical references establish that Elaphonisos was connected to the mainland by an isthmus (Strabo. iii.5.1; Ptol. iii.16.9; Pausanias iii.22.10). The present water depth in the Channel is of the order of 2–4 m, though this has still not been measured accurately throughout the area. It is apparent that submergence of 4–5 m is consistent with the existence of an isthmus at the time of first occupation, and the isthmus may have been higher than the solid bedrock as a result of tombolo wave action constructing sandy beaches on each side.

When the site had been submerged by 2–3 m, probably by *c*. 2000 cal BP, the isthmus would have been almost underwater. There are three occurrences of incised cart-tracks cut into the rock on the north shore of the Elaphonisos Channel indicating that regular transport, at various unspecified dates, was conducted to supply materials to and from Elaphonisos. The westernmost set of tracks (Fig. 17.8) is the

Figure 17.8: The westernmost set of cart tracks running into the sea at Viglafia with Elaphonisos Island in the background (Scale 1 m)

largest and most heavily incised, and suggests a last-ditch attempt to maintain dryland contact with Elaphonisos at the western and shallower end of the Channel.

Diving surveys and acoustic mapping are still needed to confirm the exact sill depth at the western end of the Channel, and to establish any possible remains of an artificial causeway. The supposed existence of a masonry causeway or fordable isthmus in use as late as the AD 1670s, attributed to the diaries of John Covel (Covel 1670–9) is incorrect. The printed texts later than 1679 (Bent 1893; Wace and Hasluck 1907–8; Waterhouse and Hope Simpson 1961; Harding *et al.* 1969) are based on a misreading of the manuscript diary by Bent in 1893, and the mistake has been repeated since then by many reputable authors, who trusted the 1893 publication (or those citing Bent). The probable absence of a shallow ford in 1670 results in, and is consistent with, a model for the stages of submergence that consists of successive downward co-seismic faulting.

Although the rate of submergence in any given millennium, or the size of downward steps of subsidence, are not yet established independently, the evidence so far indicates that the Bronze Age town area was probably inundated and awash by the time of the Roman Empire, and thus completely abandoned. This is consistent with no later construction on the site, whereas other settlements in Laconia often have continuous occupation with construction of large buildings in the Roman and Byzantine periods (e.g. Asopos, modern Plitra [Flemming 1973: 10–11]).

Future work

In 2010 the Greek–British team will continue the detailed digital survey of the site alongside oceanographic research, being carried out by Dimitris Sakellariou of the Hellenic Centre for Marine Research (HCMR), to reconstruct the ancient shoreline and the geomorphology of the seabed between Elaphonisos and Viglafia. The oceanographic research will employ three acoustic technologies: high-resolution swath bathymetry, side-scan sonar, and sub-bottom profiling. The ultimate aim of the 2010 season is to identify how and when the site became submerged. Determining when Elaphonisos became an island and the intervening strait was formed is crucial to understanding Pavlopetri's function and how ancient mariners may once have exploited this sheltered natural anchorage.

Informed by the results of the 2010 season, an underwater excavation strategy will be formulated to run over three annual seasons (2011–2013). The excavations will aim to shed light on the nature of the settlement throughout the Bronze Age, its association with contemporary settlements in Laconia and, most crucially, its role in the maintenance of maritime trade networks in the Aegean and beyond. Already, it seems that Pavlopetri was a thriving Bronze Age port, with the ceramic evidence indicating significant Cycladic and Minoan influences as well as activity spanning the critical Minoan–Mycenaean transition, which provided an important stopping off point for Bronze Age ships plying local and long distance trade routes around the southeastern Peloponnese.

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18

Submerged Sites and Drowned Topographies along the Anatolian Coasts: an overview

Mehmet Özdoğan

Turkey is a peninsula bridging the Near East, Southeast Europe, and the Caucasus, and is thus of critical importance for understanding the interactions that took place among these regions in the past. In spite of the importance given to the land route through the Anatolian plateau, the potential role of the maritime connections has been mostly overlooked, particularly for the early periods. The scarcity of prehistoric sites located on or near the coastal areas of Anatolia and the recovery of shipwrecks such as Gelidonya, Uluburun and Serçe Limanı, revealing spectacularly rich finds, have diverted interest in the field of nautical archaeology in Turkey from submerged sites to shipwrecks. Harbour installations of the Late Antique period, which are easily detectable in the sea, have also been an important concern of underwater archaeology. It is only during recent years that the importance of submerged coastlines and archaeological sites has been recognized, though only minimal research has been carried out on this topic. In this respect, the focus has been to define the changing coastal topography within the catchment areas of known archaeological sites and its impact on cultural process. Nevertheless, these studies have revealed valuable information on detecting buried or submerged sites. The recovery of a drowned Neolithic settlement in the ongoing rescue excavations at Yenikapı in Istanbul has, for the first time, aroused excitement about submerged sites in Turkey. This paper will present a survey of the status of research and a synthesis of available information on submerged sites or the potential for recovering such sites, along with a brief description of the submerged sites in the Sea of Marmara.

Keywords: Anatolia, submerged coastal sites, prehistory, underwater archaeology, Mediterranean, Aegean, Marmara, Black Sea

The distinctive coastal zones of Turkey

The Anatolian peninsula is surrounded by four different marine bodies: the Mediterranean, the Aegean, the Sea of Marmara and the Black Sea, each having distinctive features, not only in respect of their place in cultural history, but also in the dynamics of their coastal topography (Fig. 18.1). The first two (the Mediterranean and Aegean) since the earliest human activity in the region have always been a part of the global ocean system. Thus the processes affecting the coastline are similar to other open seas, i.e. eustatic changes in sea level, local tectonics, and the rate of alluvial deposition from the land. The other two marine bodies, the Sea of Marmara and the Black Sea, are inland seas that have been occasionally cut off from the world ocean system; thus the development of the coastline is far more complicated than the others, being dependent on a number of different processes taking place

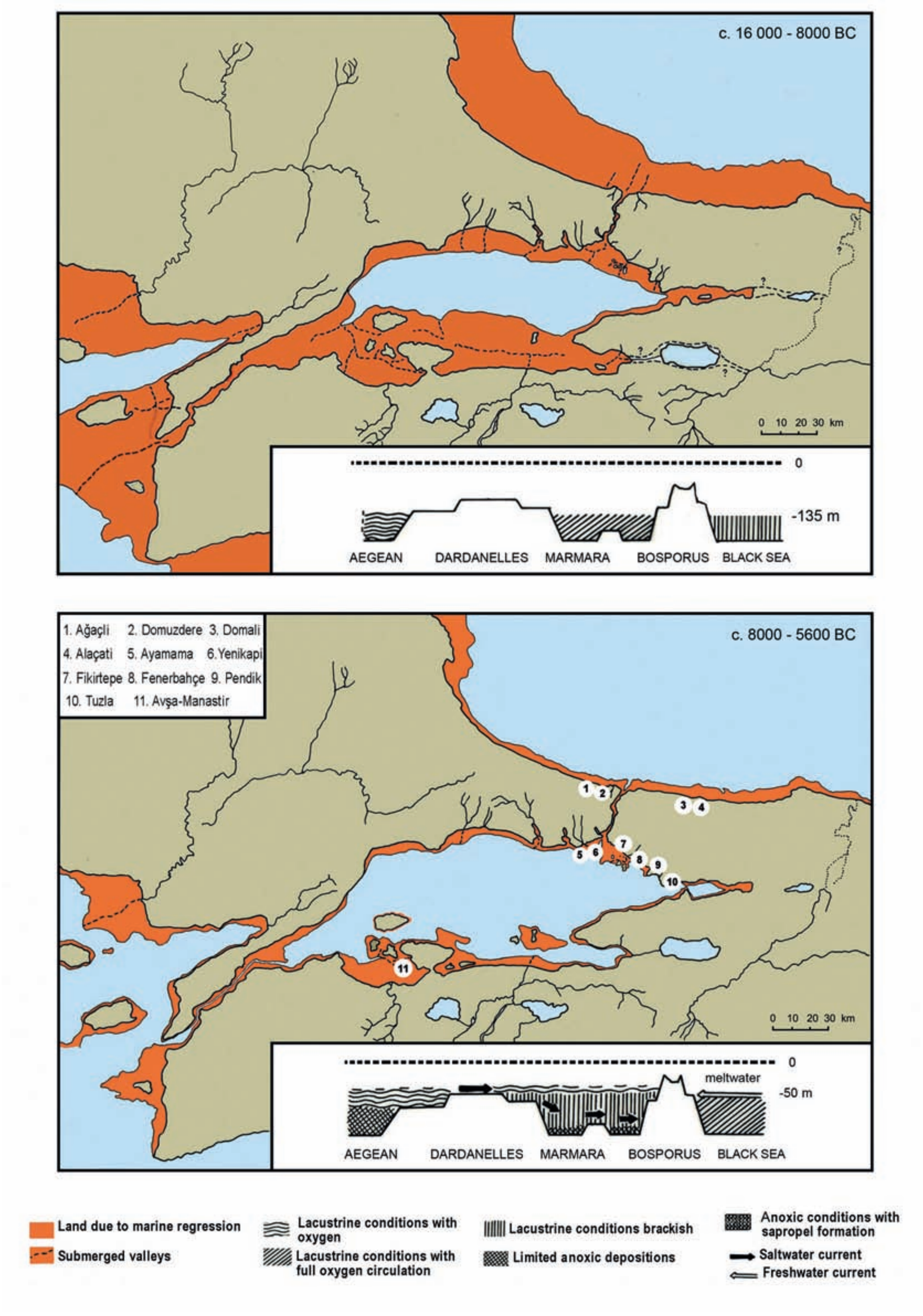

Figure 18.1: Map of the Mamara region with sites mentioned in text

both within and outside the region. Accordingly, in viewing problems related to the recovery of submerged sites, the Mediterranean and Aegean coastal areas should be treated differently from the Black Sea–Marmara system.

The Mediterranean coastal strip

The coastal strip of Turkey along the Mediterranean is defined by the steep flanks of the Taurus Mountains; since the steep slopes continue to great depths below the sea, the chances of

recovering submerged sites are minimal. On the other hand, it should also be taken into consideration that the Taurus Mountains are extremely rich in caves and some of them, such as Karain, Öküzini and Suluin, are known to have been intensively occupied during the Pleistocene. Likewise, the presence of Mesolithic and Neolithic occupation layers in some caves, such as Beldibi, Belbaşı, and Peynirçiceği, located on the lower reaches along the steeply sloping seaward flanks of the Taurus Mountains, strongly implies the existence of submerged cave sites along the coast. Here, it is worth noting that the present level of the Mediterranean was only reached at the end of the Neolithic or, possibly, later (cf. Benjamin *et al.*, this volume; Galili and Rosen, this volume).

In the eastern part of the Mediterranean there is a large deltaic plain, Çukurova (the ancient Lower Cilicia), formed by alluvial deposits of the Seyhan and Ceyhan rivers, which descend with high energy from the Taurus Mountains. The formation of this delta was extremely complex (Erol 1983), considerably changing the coastline from the Neolithic period onward. Even though the formation of the delta plain has been studied extensively, its impact on cultural history, either through the dislocation and /or burial of sites, has been appreciated only recently with the resumed excavations at Yumuktepe and Tarsus Gözlükule (Öner *et al.* 2003).

In the western sections of the Turkish Mediterranean coast, in particular to the west of the Gulf of Antalya, there are numerous submerged ancient sites that seem to have subsided owing to oscillatory movements related to neotectonics (Kelletat and Kayan 1983), the most famous and spectacular of these sites being the 'sunken city and necropolis' at Kekova (Fig. 18.2), where the almost intact remains of a partially submerged ancient settlement near Teimiusa, Simena, and Dolichiste have became a tourist attraction. All along this coastal strip, at least from Finike to Kaş, there are a number of other submerged sites dating from Late Antiquity, though less conspicuous than Kekova. Likewise, sites located along the small inlets near streams following subsidence have been buried under thick alluvial deposits; among these the so-called church of Santa Claus has been excavated at Demre (ancient Myra) and a geoarchaeological study carried out (Öner 2001). There is a general view that these sites have been submerged due to a strong earthquake that took place in either AD 142 or the 5th century AD. However, as indicated by the intact state of preservation of intricate Lydian tower tombs at Kekova, it is evident that the drowning of the sites must be due to tectonic subsidence (Erel and Adatepe 2007: 247). Moreover, the dates of the submerged sites and monuments range from the Lydian to the Byzantine period, indicating that their submergence was not an instantaneous event and that the process persisted until the Byzantine period, if not later. Apart from the above-mentioned work at Demre, and some work on submerged harbour installations, there has been almost no extensive research at any of these submerged sites.

Figure 18.2: Kekova Karaada: partially submerged Byzantine remains demonstrate the impact of tectonics during the Late Holocene (Photo: M. Özdoğan)

The Aegean coastal strip

The coastal strip along the Aegean, unlike the Mediterranean, is discordant; the mountains are almost perpendicular to the coast and there is an extensive coastal shelf on which the islands of the eastern Aegean are located. Accordingly, changes in either land (due to tectonic movements) or sea level has had much more exaggerated consequences in exposing or drowning the shelf. During the regression phases, the coastline extended considerably westwards and almost all of the present-day east Aegean islands were part of the mainland. The coastline of the Upper Palaeolithic period receded gradually as sea level rose; first the deeply incised valleys were drowned, then the distance between the islands and the mainland gradually

increased. Gulfs penetrating deep inland, which formed during periods of transgression, were later filled in by alluvial deposits (Kraft *et al*. 1977; Kayan 1996; Brückner 1997), thus hindering site discovery. Accordingly, unless they were located on high ground, the chances of finding sites earlier than the 4th millennium cal BC along the Aegean coast are slight; the sites have been either submerged or deeply buried under alluvial deposits (Çilingiroğlu *et al*. 2004). The problems related to the changing coastline and submerged archaeological sites in the Aegean have been much more extensively studied than in the Mediterranean region, as geomorphological processes had drastic consequences for the settlement history, even during the historic periods. Owing to the discordant topography of the coastline, some of the most important harbour towns, such as Miletus or Ephesus, remained kilometres away from the sea. Likewise, some famous sites such as the Artemision of Archaic Ephesus were deeply buried under alluvial deposits (Kayan 1988, 1999). Thus, until recently, in attempts to define the succession of palaeocoastlines, the focus of research has been on the delta formations of major river systems such as the Menderes and Gediz. The research conducted hitherto has been based mainly on geomorphological observations (Erol 1997), although there are now more extensive multidisciplinary studies supported by coring and soil analysis. Among the work on palaeocoastlines, that at Madraçay (Lambrianides 1992; Lambrianides and Spencer 2007), Miletos, Ephesus and Myous (Brückner *et al*. 2002; Brückner 2003), and Artemision (Kayan and Kraft 1997) is worth noting.

It is now evident that alluviation and sea-level change had a drastic impact on the coastline, making recovery of sites, unless located on high cliffs, almost impossible; however, there are some partially submerged early sites near the present coast, as in the Mediterranean, that show the effects of active tectonic movements. Among the most significant and informative studies in this field is the ongoing work at Limantepe harbour (Goodman *et al*. 2004, 2009; Artzy *et al*. 2007), uncovering the submerged remains of an Early Bronze Age settlement extending from the land and dipping into the sea. Considering that marine archaeology in Turkey has focused mainly on shipwrecks, the work at Limantepe should be acknowledged as the first underwater excavation of a prehistoric settlement site in Turkey.

Another major undertaking is being carried out within the context of the Troy project at the critical confluence of the Dardanelles with the Aegean. Even though the main objective of the study, initially undertaken by G. Rapp in 1977 as an extension to the stratigraphic sections described by Blegen's team in 1937 (Rapp and Gifford 1982), was the investigation of the plain near Troy, it was later developed as an extensive regional project by İ. Kayan. The present study, supported by over a hundred core samples and soil profiles, covers both the Aegean coast near Beşiktepe and the floodplain of the Karamenderes River near Troy (Kayan *et al*. 2003). The evolution of the coastal topography since the end of the Pleistocene has been defined more precisely and correlated with the settlement history of the Troas region. Another significant outcome of this study has been the recovery of an early prehistoric settlement buried under alluvial deposits (Kayan 2009).

The importance of the Aegean basin in understanding the past relations between the east and the west is self evident; however, until recently very little was known of the early prehistoric cultures of the region, in particular the Palaeolithic, Mesolithic and Neolithic periods, not only because of the paucity of research, but also the scarcity of sites identified in surface surveys (van Andel and Shackleton 1982; Lambeck 1996). On the other hand, unbiased assessments of the assemblages recovered previously are clearly indicative of the significant role played by maritime connections in early prehistory. It is now evident from the distribution pattern of Melian obsidian that seafaring was already taking place during the Mesolithic and Neolithic, and that in the dispersal of Neolithic traits maritime routes played an important role (Perlès 2005; Broodbank 2006; Runnels 2009; Ammerman *et al*., this volume). Discussions on this issue have become more frequent with the recent discoveries of Palaeolithic and Mesolithic lithic assemblages on Crete (Hammond 2010; C. Runnels, pers. comm. 2010), indicating more clearly than before the need for further research in prehistoric maritime archaeology and underwater investigations.

The Sea of Marmara

The Sea of Marmara (Fig. 18.1) is a closed inner sea connected to the global ocean system through a relatively long but shallow strait known as

the Dardanelles. In fact, the Dardanelles is the start of a chain of inner, land-locked seas that are connected to one another by narrow straits or channels. This complex system beginning at the Dardanelles continues through the Sea of Marmara – Bosporus – Black Sea – Kerch Strait – Sea of Azov – Maynch Channel – Caspian Sea – Uzboy Channel – and Lake Aral. Even though the connection of this system with global sea level is controlled by the Dardanelles, the water discharge of rivers running into the Black Sea–Caspian system becomes the main agent when the Dardanelles is not functioning. Accordingly, until global sea levels reached -40 m MSL (high enough to pass through the Dardanelles), the levels of Marmara and the other aforementioned water bodies varied according to the water input from either rivers or glacial meltwater. The system is further complicated by the presence of differences in the masses of the water bodies, warm and saline waters on one end, and fresh and cold at the other. Nevertheless, it is evident that during the entire span of the Neolithic, Marmara was a brackish lake, considerably shallower than it is at present.

The Black Sea, the main component of this complex system, has been extensively studied since the end of the 19th century, mainly by Russian scientists; numerous publications presenting a conspectus with extensive bibliographic references exist (e.g. Deuser 1972; Schrader 1978; Usher and Supko 1978; Yanko-Hombach 2007). Similarly, the questions around when and how the Bosporus provided a connection between the Sea of Marmara and the Black Sea have a long history of controversy (Gökaşan *et al*. 1997). However, the effects of this system on the cultural environment were first reported by S. Erinç (1954) and further defined by D. Stanley and C. Blanpied (1980). However, the significance of this system was mostly overlooked until W. Ryan and W. Pitman theorized that the opening of the Bosporus was due to a cataclysmic event. They concluded that after the invasion of waters from the Aegean, Marmara overflow into the Black Sea basin inundated vast areas; dislocated communities fleeing from the flood-like rise of the marine body moved into the Near East, triggering the beginning of civilization there (Ryan and Pitman 1992, 1998). The linking of this scenario to the Noah's flood epic, though resulting in considerable controversy, also helped to initiate large-scale research in and around the Bosporus (Okay and Şengör 1994; Ryan *et al.* 2004; Yanko-Hombach *et al.* 2007, this volume). Even though there is still no consensus on whether or not the initial connection was from the Black Sea to Marmara or vice versa, nevertheless it is evident that until global sea level rose to -40 m, high enough to flow through the Dardanelles, Marmara remained a brackish lake, detached from the Black Sea. Regardless of the debate, the final infilling of the Marmara basin took place during the final stages of the Neolithic, i.e. by the second half of the 6th millennium cal BC. It follows that all coastal sites of the Mesolithic and Neolithic periods have been submerged. Until recently, the only firm evidence on this issue was the marine fauna of Fikirtepe, a site on the Asian side of Istanbul, dated to the beginning of the 6th millennium cal BC, revealing a mixture of brackish and saline species (Boessneck and von den Driesch 1979), seemingly reflecting the changing marine environment.

The much-needed evidence to correlate the changing marine conditions of the Marmara basin with the cultural history of the region has now been recovered in the rescue excavations at Yenikapı in İstanbul (Kızıltan 2007; Kocabaş 2010). This site, located on the European side of Istanbul within the historic centre, has been the scene of extensive excavations since 2008 for the construction of a railway tunnel through the Bosporus (Fig. 18.3). The excavations at Yenikapı have revealed a long sequence from recent back to the Neolithic, yielding stratigraphic series with indicators of both cultural and natural events (Algan *et al.* 2009, 2010). Prior to the excavations, Yenikapı was known to be the location of the ancient harbour of the Teodosius

Figure 18.3: Yenikapı. General view of the operation area. Under each shed are the remains of a Byzantine shipwreck (Photo: Bekir Köşker, courtesy of the Archaeological Museums of Istanbul)

Figure 18.4: Yenikapı. One of two Neolithic burials found lying on a wooden platform. Archaeological material found several metres below the surface and below the current level of the Sea of Mamara, provides direct evidence for lower sea level during the Neolithic (Photo: Bekir Köşker, courtesy of the Archaeological Museums of Istanbul)

at the confluence of the Bayrampaşa/Lykos River, which was subsequently filled in and built over. The construction project necessitated a number of auxiliary units, such as subway connection, energy substation, passenger transfer centre, and parking facilities; thus the rescue excavations were conducted in an exceedingly large area dug down to the Miocene bedrock, exposing an eroded palaeolandsurface, partially shaped by an ancient river system. Later, possibly during the Pleistocene, the Bayrampaşa/Lykos River, which flowed into the Marmara lake, incised a new course through this landsurface.

The earliest cultural layer, revealing architectural remains of the Archaic Fikirtepe Culture, *c*. 6400 cal BC, was found sitting directly on the bedrock. Evidently, the settlement consisted of wooden-post constructions reinforced with stone alignments and wattle and daub. Owing to the extent of the construction area, it was not possible to make any estimation of the size of the prehistoric settlement; however, it is evident that it extended beyond the area exposed. As no coastal features associated with this layer have been uncovered, it is clear that the site was located some distance from the Marmara lake. The architectural remains were uncovered at 6.5 m below the present level of the Sea of Marmara, but there is a depression, an ancient meander, which partially encircled the settlement. Its deepest part is 9 m below the modern landsurface, which indicates that the level of the Marmara must have been lower still.

The settlement seems to have continued more or less in the same location for about a thousand years, as typical pottery assemblages that previously were attested from coastal areas along the eastern Marmara (Özdoğan 1999) have been recovered from deposits overlying the architectural remains of Archaic Fikirtepe. The archaeological assemblage thus recovered comprises the Classical phase of Fikirtepe, the following cultural stages equivalent to phases 4 and 3 of the Yarımburgaz Cave just to the west of İstanbul along the Küçük Çekmece lagoon, and material akin to the Toptepe Culture. Transgression by the rising Marmara must have begun during the time of the Toptepe Culture, *c.* 5200–4900 cal BC, gradually washing away the cultural accumulation into the nearby depression. Thus, only the architectural remains of the earliest horizon, together with pits and burials dug down from the upper levels, have remained *in situ* (Fig. 18.4). Likewise, around the site the remains of numerous trees (either planted intentionally or growing naturally) were recovered, some showing cut-marks and others found still standing.

It is now known that the depression adjacent to the site had a distinct sequence, alternating between anoxic swamp conditions with sapropel deposits and normal lacustrine stages, and occasionally drying up. Excavations in this ditch-like depression have revealed a rich and varied assemblage of archaeological and botanical material which has remained in an excellent state of preservation due to anoxic conditions; noteworthy among them are wooden artefacts including oars, bows, spears and digging tools, and food remains. During the dry periods, at least a part of the surface of this depression was used as burial ground, in which four cremation burials and a cremation pit were found.

Covering the archaeological remains was a sandy deposit with marine molluscs reflecting a beach environment. The stratigraphic sequence continued with thick layers of cobbles, evidently deposited in a high-energy marine environment, followed by deposits relating to the period when the area became the harbour of Roman and Byzantine Istanbul. Along with various harbour installations, well-preserved remains of

35 Byzantine ships have also been recovered. In the final stage, during the Ottoman period, the harbour was filled with alluvial and colluvial deposits from the Bayrampaşa/Lykos River.

The excavations at Yenikapı are still in progress and will continue for at least another year; the amount of material and data collected is substantial and it will take some time for everything to be processed and the results of specialist studies to be integrated. Nevertheless, Yenikapı has already prompted an interest in submerged sites and the alternating stages of the Marmara system. Already there are a number of locations along the coastal areas of Istanbul where Neolithic to Bronze Age materials have been reported, though they are yet to be studied (Özdoğan 2009a, 2009b). Neolithic and Chalcolithic sherds were recovered at Ayamama, in the European section of İstanbul during the construction of a drainage channel below the present level of the sea. More significant to the topic of submerged prehistory is the recovery of four Early Bronze Age vessels (dating to *c*. 2600 cal BC) at Fenerbahçe Bay. The vessels found by divers at a depth of *c*. 10 m show no signs of erosion, and it is possible that a submerged prehistoric site exists here at depths comparable to Avşa Manastır Mevkii and Yenikapı. Unfortunately, proper recording and documentation were not carried out at either of these sites.

The Marmara Sea basin has been further complicated by tectonic movements. A major fault line passes through the centre of the basin, and has led to subsidence along significant parts of the south coast, mainly between Avşa Island and the Gulf of İzmit. As there have been no underwater archaeological surveys, we can only assume that there must be a number of submerged archaeological sites along the length of this palaeocoastline (Özdoğan 2003). The only site that has been reported is at Manastır Mevkii on Avşa Island (Fig. 18.5) where a large, partially submerged, Bronze Age mound is known to exist (Günsenin 2001; Özdoğan 2003, 2007: 665), although this site has not been fully studied. Visible on the land are the partial remains of a Byzantine monastery; the fact that parts of that building extend into the sea indicates that oscillatory movements have persisted, at least until the Medieval period. On the beach, almost at sea level, at least two architectural layers, one belonging to Early Bronze Age I, and the other to Early Bronze Age III, are detectable under a thick layer of colluvium. The archaeological

Figure 18.5: Avşa Island, Manastır Mevkii. The submerged Bronze Age mound is in the small gulf (Photo: M. Özdoğan)

Figure 18.6: Typical geometric microliths of the Epipaleolithic period, from the coastal sand dune sites of Ağaçlı and Domuzdere along the Black Sea

layers dip and continue under the sea to a depth of 10 m where numerous ceramic vessels and metal objects datable to the Troy II period have been collected by an amateur diver. At the periphery of the mound, archaeological material datable to the Epipalaeolithic (Fig. 18.6) and Early Iron Age is being washed out due to wave erosion. A thorough interdisciplinary study of the submerged archaeological sites could yield valuable data on the nature and chronology of tectonic activity in the area.

The Black Sea

Like the Mediterranean coast, the coastal strip along the Black Sea is backed by steep mountain slopes, in this case the Karadeniz Dağları/Black Sea Mountains, running parallel to the coastline. With the exception of small deltaic plains at the confluence of the Sakarya, Yeşilırmak and Kızılırmak rivers, which run from the Caucasus in the east to the Bosporus in the west, there are no other coastal plains, inlets, or gulfs. Even though the development of the Black Sea basin has been much more extensively studied than that of the Sea of Marmara (Emery and Hunt 1974; Degens and Paluska 1979; Aksu *et al*. 2002; Preisinger and Aslanian 2004; Yanko-Hombach *et al*. 2007), there is still considerable controversy surrounding the sequence of Holocene sea levels (Chepalyga 2007).

Our knowledge of the prehistoric cultures along the Black Sea coastal area of Turkey is minimal. With the exception of Mesolithic dune sites, no settlement site earlier than the 8th century BC has been recorded. Thus it seems justifiable to suggest that sites of the Neolithic, Chalcolithic, and Bronze Age must have been submerged due to changes in the level of the Black Sea (cf. Filipova *et al*., this volume). The only evidence from the Turkish part has been the restricted work done off the Sinop coast (Ballard *et al*. 2001, 2002) revealing some submerged remains of an undetermined period. In this respect, the work done along the Bulgarian coast in the western section of the Black Sea has been most instructive and significant. About a dozen submerged settlement sites, ranging in age from Late Chalcolithic to Bronze Age, have been uncovered (Panajotov 1991; De Boer 1994; Draganov 1995; Stanimirov 2003). It seems reasonable to assume that a similar situation exists along the Turkish coastline, which would explain the lack of coastal sites.

The evidence from the Bulgarian coast presents a new problem that has been overlooked; almost all marine geologists working in the Marmara basin agree that the water exchange between the Marmara Sea and the Black Sea was established by the 6th millennium cal BC and that subsequently there was no major fluctuation in the level of the sea (Kayan 1988, 1996; Fairbanks 1989). However, submerged sites off the Bulgarian coast fall into the time-range from the 4th to the 2nd millennium cal BC, and some of these sites are at sea depths of up to 12 m (Draganov 1995). This situation has yet to be explained (Özdoğan 2003).

Concluding remarks

The underwater archaeology of prehistoric landscapes is not even at an incipient stage in Turkey; the field is overshadowed by the famous work carried out on maritime sites such as the Serçe Limanı or Uluburun shipwrecks. Similarly, there have been no serious attempts either to define or to survey submerged palaeocoastlines. Accordingly, with the exception of the recent work at Yenikapı, that which has been noted herein can be considered generalizations either deduced or extrapolated from observation or limited evidence. Nevertheless, growing interest in submerged harbours, mostly belonging to the Late Antique period, has provoked some interest in submerged coastlines. It is evident, however, that inundation of archaeological sites and especially the monumental remains of the Hellenistic, Roman or Byzantine periods is due to recent tectonic activity, and not major changes in sea level. In spite of the complex nature of the water exchange between the Black Sea, the Sea of Marmara and the Aegean (which had long been noted), it is only during the last decade that this system has been the subject of intensive multidisciplinary studies, bringing together geologists, marine geologists, and archaeologists. In this respect, the ongoing rescue excavations at Yenikapı, are revealing concrete evidence of changes that took place in the marine environment of Marmara during the Early and Middle Holocene. This, in relation to a submerged Neolithic settlement, provides a unique opportunity to correlate archaeological evidence with a geological sequence. Nevertheless, the significance of the 4th to 3rd millennium cal BC discoveries of submerged sites in the Black Sea by Bulgarian colleagues remains to be assessed.

Considering the significance of the Anatolian peninsula to cultural history, as a bridge between the Near East, southeast Europe and the Caucasus, much more data than are currently available will be required to accurately describe the prehistory of this region. This paper has attempted to highlight the potential of marine archaeology to add to our knowledge not only of cultural history, but more particularly the interaction between prehistoric communities and the changing natural environment.

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19

Palaeoecology of Submerged Prehistoric Settlements in Sozopol Harbour, Bulgaria

Mariana Filipova-Marinova, Liviu Giosan, Hristina Angelova, Anton Preisinger, Danail Pavlov and Stoyan Vergiev

In addition to archaeological and geological investigation of submerged prehistoric settlements in the harbour of Sozopol (southern Bulgarian Black Sea coast), two cores were analyzed for pollen and spores, dinoflagellate cysts, non-pollen palynomorphs, and micro-charcoal. The cores provide detailed information about the vegetation and climate of periods with abundant archaeological evidence. Four local pollen assemblage zones based on arboreal pollen/non-arboreal pollen (AP/NAP) ratios are distinguished. A detailed reconstruction of the past vegetation reveals the extent of anthropogenic influence on the area. Three AMS radiocarbon determinations show that the palaeoecological record starts at c. *4139 cal BC. The palynological and geoarchaeological data confirm the existence of anthropogenic activity and settlement during the final stage of the Late Eneolithic (*c. *4100–3850 cal BC) and the second phase of the Early Bronze Age (*c. *3500–2650 cal BC). These two archaeological cultural stages were interrupted for about 500–1000 years because of the rise in the level of the Black Sea, as suggested by the increase of euryhaline marine dinoflagellate cysts, and/or land subsidence.*

Keywords: Black Sea, sea-level rise, Sozopol harbour, Eneolithic, Chalcolithic, Bronze Age, palaeoecology, human impacts, vegetation change

Introduction

The rich archaeological record along the south-western Black Sea coast has attracted the attention of many scientists in different fields of investigation. The submerged prehistoric settlements in the harbour of Sozopol (Fig. 19.1) have yielded remains of the Late Eneolithic (Eneolithic is also known as Chalcolithic or Copper Age) and Early Bronze Age (Draganov 1995, 1998; Angelova and Draganov 2003). Archaeological evidence of human occupation during the Bronze Age has also been found in the nearby Bay of Urdoviza (Kiten) (Porozhanov 1991).

Valuable palynological information relating to the palaeoenvironmental conditions of the southern Bulgarian Black Sea coast (vegetation, climate, and sea-level fluctuations) is available from studies of lacustrine and marine sediments, and from sediments of the Veleka River estuary (Bozilova and Beug 1992; Filipova-Marinova 2003a, 2003b, 2007; Wright *et al.* 2003; Filipova-Marinova *et al.* 2004; Atanassova 2005). However, evidence relating to human activity is insignificant in these previous studies.

Some information about palaeoecological conditions and especially about human impact on vegetation comes from palynological investigations of the core from Quadrant 'F' from the Bay of Urdoviza (Kiten), 10 km south of Sozopol (Bozilova and Filipova-Marinova 1994). The pollen diagrams generally demonstrated a long

period of forest development for the greater part of the Holocene interrupted by distinct phases of human activity during the Early Bronze Age (Kuniholm *et al.* 2007).

The aim of the present investigation is to trace changes in environment and human activity along the southern Bulgarian Black Sea coast. To address this question, two cores from Sozopol harbour were analyzed for pollen, dinoflagellate cysts, and other non-pollen palynomorphs (NPP). Radiocarbon dating was also performed.

The study area

Topography and geology

The southern Bulgarian Black Sea coast (Fig. 19.1) consists of sandy bays with lagoon lakes interrupted by rock ridges. Rocky slopes gradually rise up to about 200–400 m altitude at a distance of *c.* 3–4 km from the coast. Ridges, slopes, and mountains are composed of andesite and syenite. In the area investigated geological faults run from the Strandzha Mountains to the Black Sea (Kanev 1960).

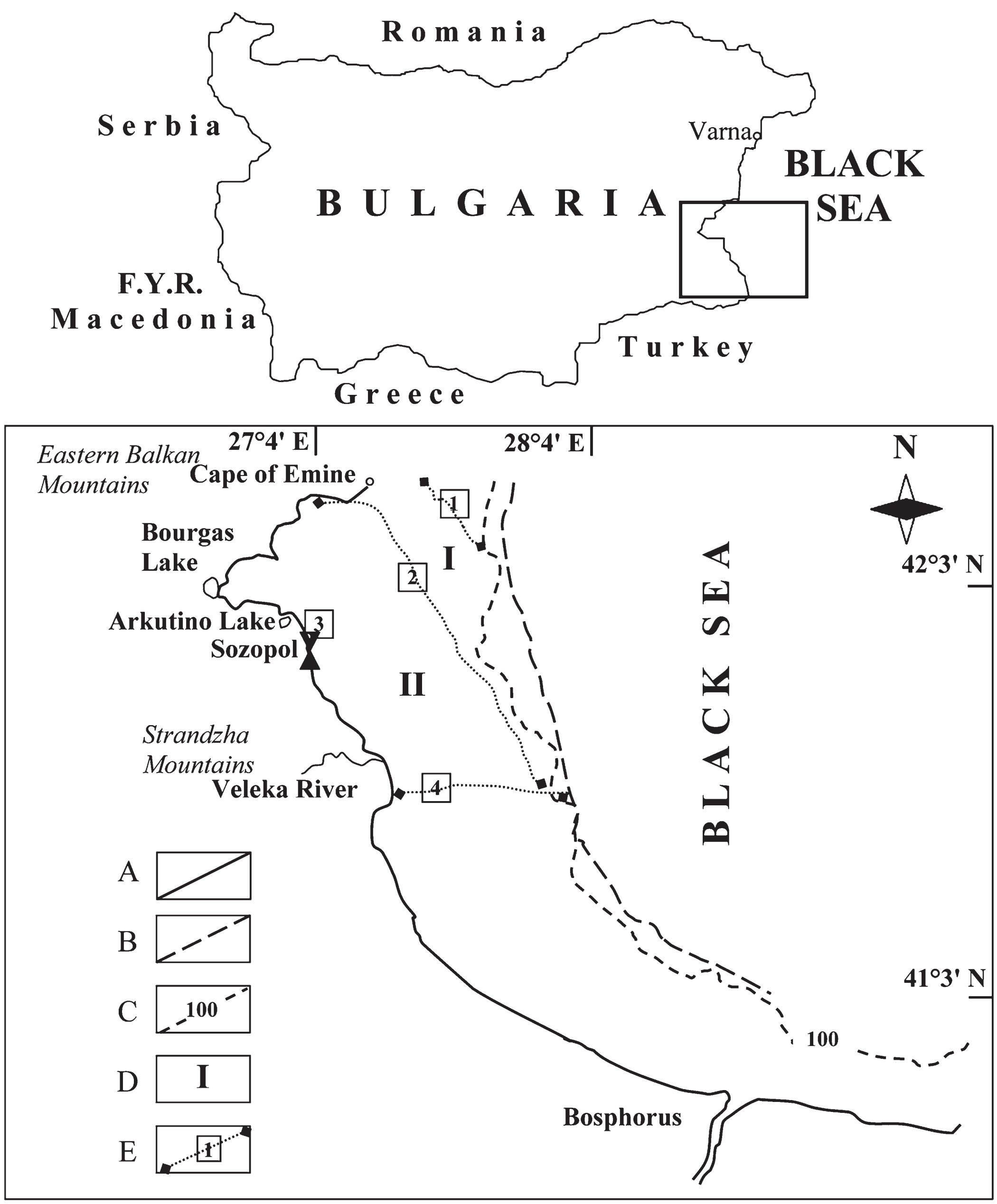


Figure 19.1: Schematic diagram of the area investigated. A: Coastline; B: Boundary between the shelf and the continental slope; C: 100 m isobaths; D: Basic tectonic zones, I Eastern Balkan Range, II Bourgas Depression; E: Basic fault zones reflected in the bottom relief, 1 Pre-Balkan fault, 2 Hind Balkan fault, 3 Sozopol fault, 4 Eastern Rezovo fault

Climate

Along the Southern Bulgarian Black Sea coast the climate is transitional Mediterranean with dry summers and mild, humid winters. Mean annual precipitation is estimated to be 500–600 mm, with most rainfall during the autumn–winter season. Mean January temperature is 2–3°C, and mean July temperature is 22°C. The summer dry period lasts from July to September. Winds come mostly from the southeast, but occasionally from the northeast (Velev 2002).

Vegetation

According to Bondev (2002) the area is included in the Black Sea province of the European deciduous forest area. Near the Black Sea coast, forests with some Mediterranean elements such as *Carpinus orientalis* Mill., *Phillyrea latifolia* L., *Fraxinus ornus* L., *Quercus pubescens* Willd., and *Celtis australis* L. occur. Forests of the more continental species occur on lowland sites and hills and in the Strandzha Mountains. They are mainly composed of *Quercus cerris* L., *Quercus frainetto* Ten., *Quercus polycarpa* Schur., and *Carpinus betulus* L. South Euxinian forests of *Fagus orientalis* Lipsky with undergrowth of evergreen shrubs (*Rhododendron ponticum* L., *Ilex aquifolium* L., and *Daphne pontica* L.) are distributed along the more humid ravines in the Strandzha Mountains. Periodically flooded forests (known as 'Longoz') dominated by *Fraxinus oxycarpa* Willd., *Ulmus minor* Mill., *Carpinus betulus* L., *Quercus pedunculiflora* C. Koch, and *Alnus glutinosa* (L.) Gaerth. with lianas (woody vines), including *Hedera helix* L., *Periploca graeca* L., *Smilax excelsa* L., *Vitis vinifera* L., and *Clematis vitalba* L. occur along the rivers and lakes. Herb communities with a prevalence of *Leymus racemosus* (Lam.) Tzvelev ssp. *sabulosus* Hochst, *Ammophilla arenaria* (L.) Link, *Centaurea arenaria* Bieb. ex Willd, and *Galilea mucronata* (L.) Pal., as well as shrub communities with a prevalence of *Cionura erecta* (L.) Grsb., are distributed on beach sand and dunes.

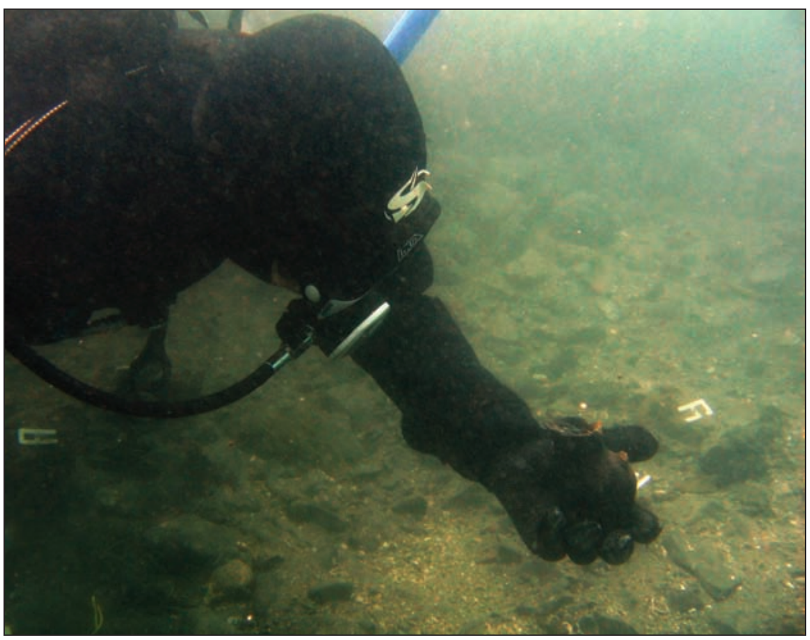


Figure 19.2: Excavation of the Early Bronze Age layer of the submerged settlement in Sozopol harbour (Photo: H. Angelova)

Archaeological background

Underwater archaeological investigations at the Bulgarian Black Sea coast over the past 20 years have made it possible to collect some information about submerged prehistoric settlements. These settlements belong to two chronological periods. Some of the prehistoric settlements (e.g. Varna and Sozopol) were founded during the Late Eneolithic. The Late Eneolithic settlement in Sozopol harbour can be placed between the end of Varna Culture (phase III, *c*. 4340 cal BC) and the beginning of the Cernavoda I Culture (*c*. 4100 cal BC). Draganov (1995) dated the Late Eneolithic in Sozopol between 4100 and 3850 cal BC. The dendrochronological data of oak piles (Figs 19.3 and 19.4) retrieved from the Late Eneolithic site in Sozopol harbour, *c*. 7 m below present sea level, show a 224-year tree ring chronology and an AMS radiocarbon determination of *c*. 4140 cal BC (Kuniholm *et al.* 2007). The Eneolithic settlements in Sozopol harbour were either flooded owing to sea-level rise or because of tectonic subsidence. The date of this inundation corresponds to the archaeological hiatus known as the 'Transitional Period', dated in Bulgaria at 4000–3200 cal BC (Bojadziev 1995).

After 3200 cal BC the sea began to withdraw and the Bay of Sozopol became habitable once more. Some Early Bronze Age settlements then developed on the remains of the Late Eneolithic settlements (e.g. Sozopol); others sprang up in entirely new locations (e.g. Atiya, Ropotamo, Urdoviza, and Akhtopol). These settlements existed mainly during the second phase of the Early Bronze Age (2780–2504 cal BC; Ezerovo Culture, phases VI–V) (Bojadziev 1995). The nearby, submerged settlement of Urdoviza (Kiten) is dated to 2850–2600 cal BC (Görsdorf and Bojadziev 1997) and could be compared to the Cernavoda–Ezerovo Culture

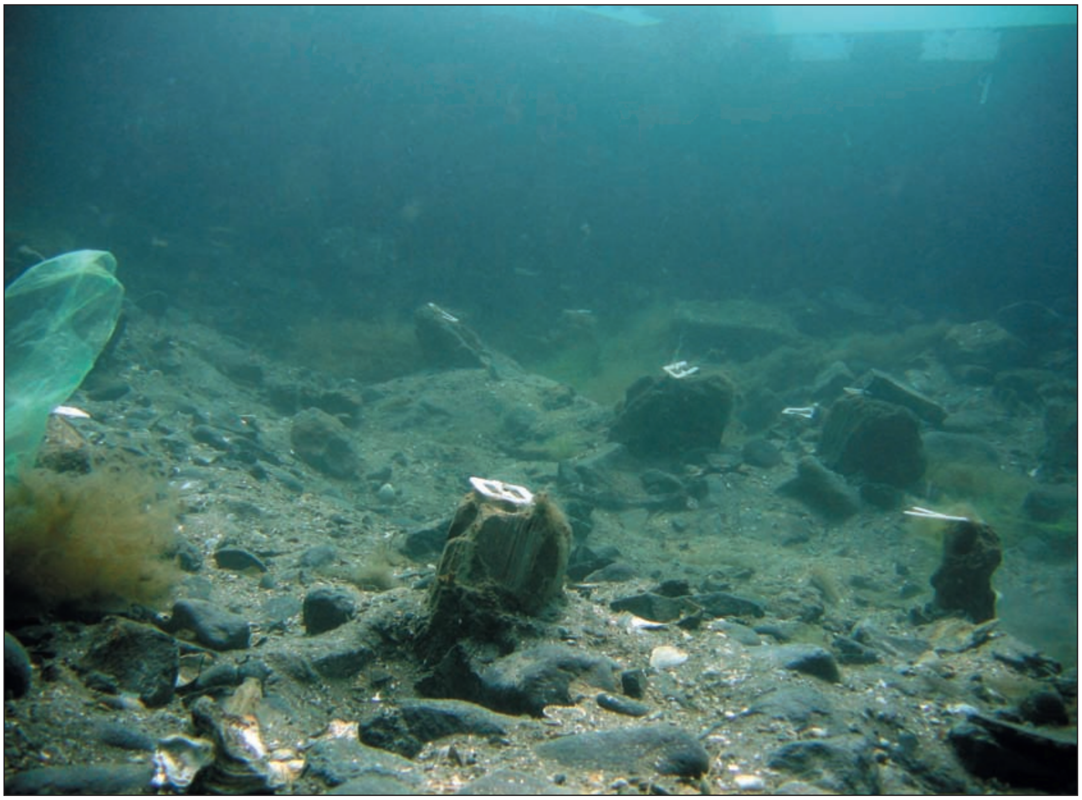


Figure 19.3: Vertical piles in Sozopol harbour, dated by dendrochronology to the Eneolithic period (Photo: H. Angelova)

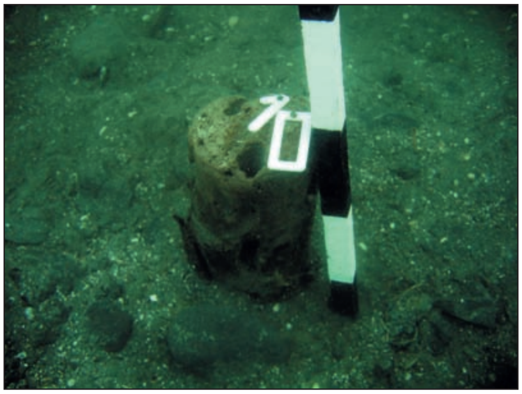


*Figure 19.4: Eneolithic pile. Prior to the archaeological excavation its upper end was shaped by erosion and biological decomposition at the seafloor. The vertical holes in the timber are made by piddocks (*Pholadidae*) (Photo: H. Angelova)*

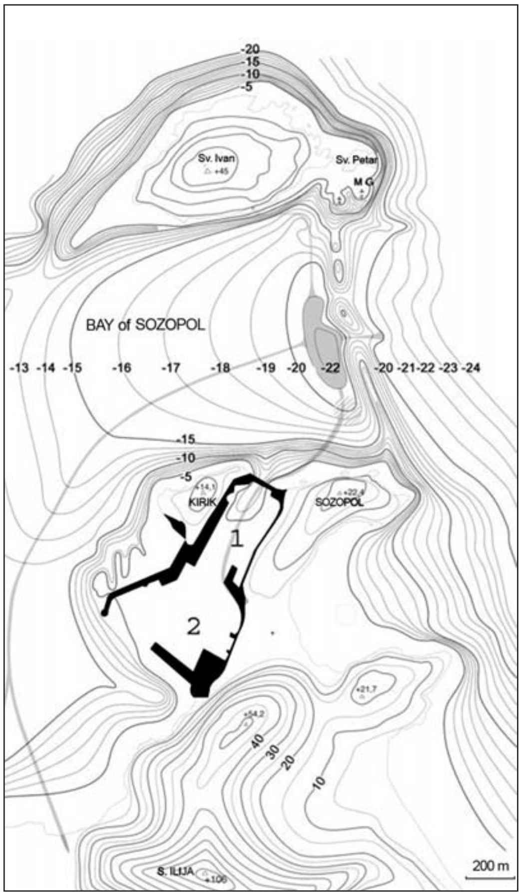


Figure 19.5: Geomorphological and bathymetric map of the Bay of Sozopol with the location of both investigation zones of the prehistoric settlements indicated

(Ezero VI–IX, 2900–2700 cal BC) (Kuniholm *et al.* 2007). Dendrochronological analysis of preserved wooden piles shows that this prehistoric settlement has the longest Early Bronze Age chronology (224 years) in the Balkan and Aegean area (Kuniholm *et al.* 1998, 2007).

Material and methods

Coring

The Bay of Sozopol is situated in the southwestern Black Sea area (Fig. 19.1). Three islands occur in the area: Kirik, Sveti Ivan, and Sveti Petar (Fig. 19.5). Sozopol harbour includes two zones of investigation: Sozopol-1 and Sozopol-2.

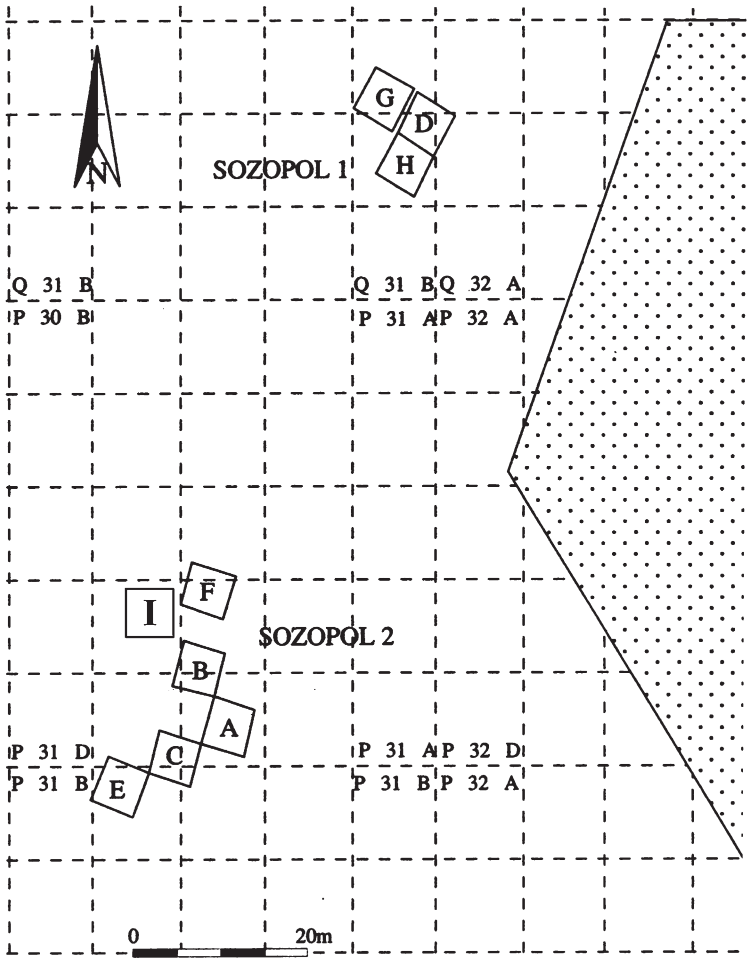


Figure 19.6: Schematic diagram of the location of the investigated quadrants in Sozopol harbour

A grid was laid over the site with the aid of theodolites located on shore. The working squares (5 × 5 m) formed part of larger squares (100 × 100 m) that were connected to topographical altitudes noted on the shore. To assist stratigraphical observations a rigid square network made of solid metal sheets was put in place. The seabed was removed in layers of 5–10 cm by ejectors and a low-pressure compressor. Nine connected quadrants, 5 × 5 m in size, were excavated in these zones (Fig. 19.6). Three of the quadrants contain only Early Bronze Age material (A, C, and E), three contain Early Bronze Age material and, below a hiatus, Eneolithic material (B, F, and I), and three contain only Eneolithic material (D, G, and H). During the construction of the harbour the overlying sediments in quadrants D, G, and H were damaged.

The material for the present investigation was collected using *Dachnowsky* coring equipment from two submerged settlements (Figs 19.5 and 19.6):

- Sozopol-1 investigation zone – Quadrant 'D' (210 cm core), water depth 4.3–4.6 m, with coordinates 42°25´85″ N, 27°41´88″ E;
- Sozopol-2 investigation zone – Quadrant 'I' (190 cm core), water depth 5.0–5.1 m, with coordinates 42°25´88″ N, 27°41´41″ E.

Radiocarbon dating

Two samples of wood from core 'I' and one sample also of wood from core 'D' from the levels where anthropogenic indicators started to increase were submitted for AMS dating. The radiocarbon dates on core 'I' were done at the Woods Hole Oceanographic Institute and on core 'D' at the VERA Laboratory of the University of Vienna. The results are shown in Table 19.1. The data cover the time span between *c.* 4139 cal BC and *c.* 3227 cal BC, and correspond to the Late Eneolithic and Early Bronze Age according to the radiocarbon data for Bulgarian prehistory (Görsdorf and Bojadziev 1997).

Pollen analysis

Samples for pollen analysis were taken every 10 cm through the core and processed according to the acetolysis method (Faegri and Iversen 1989) slightly modified to remove the mineral component with hydrofluoric acid (Birks and Birks 1980). By this procedure, some dinoflagellate cysts can be lost. Pollen types were determined by comparison with the reference collection of the Museum of Natural History

Table 19.1: AMS radiocarbon determinations for Sozopol cores 'I' and 'D'. The samples dated were single pieces of wood. Calibrations performed with CALIB 6.0 (Stuiver and Reimer 1993; Stuiver et al. *2005), using the IntCal09 curve (Reimer* et al. *2009)*

Core/Lab. ID	Depth (cm)	^{14}C Age BP	Median Probability Age (cal BP)	Median Probability Age (cal BC)	Material dated
Sz-I/OS-58077	35–45	4560±40	5177	3227	Charcoal
Sz-I/OS-57882	155–165	5170±30	5929	3979	Charcoal
Sz-D/VERA-1652	65–70	5310±40	6089	4139	Uncarbonized wood

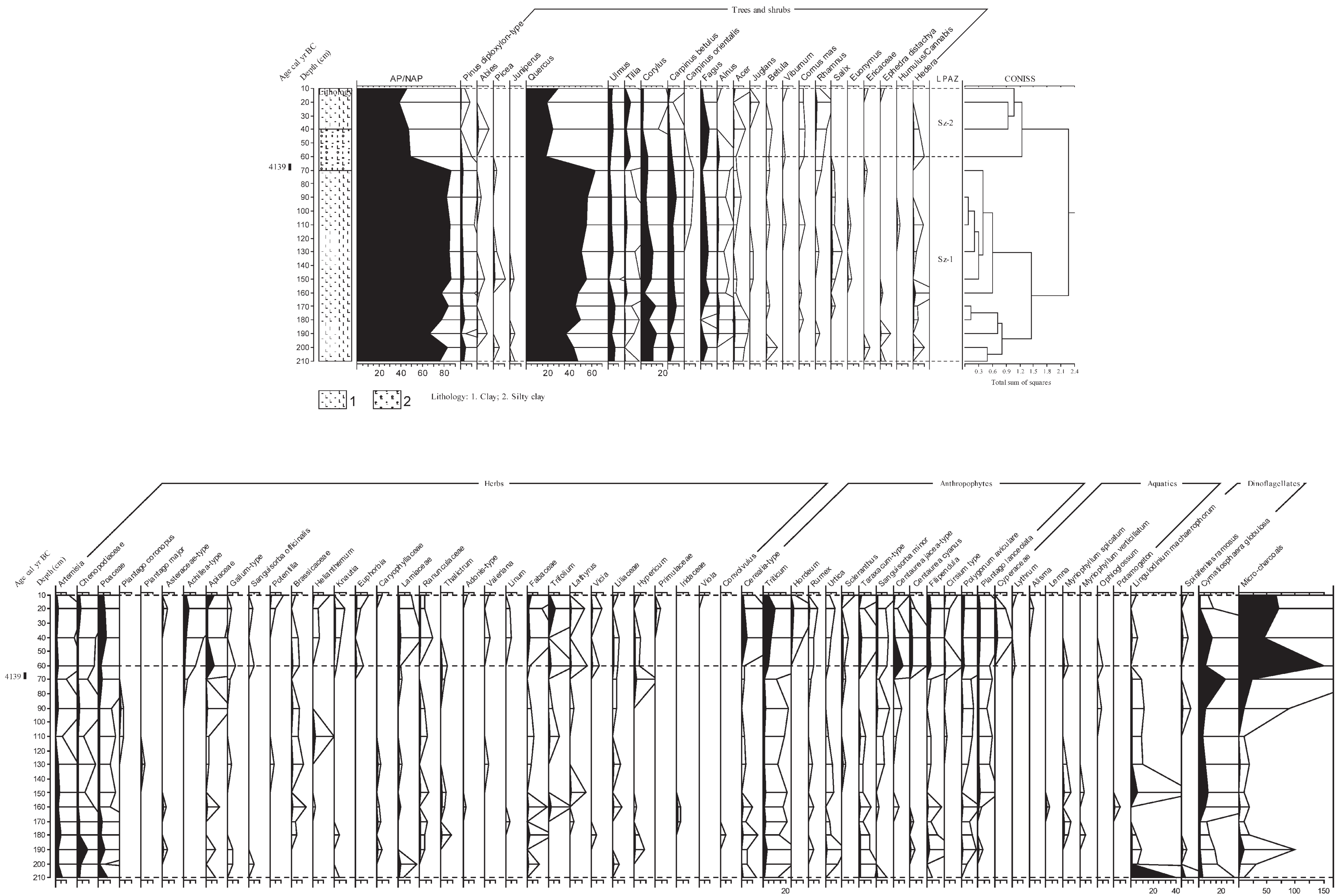


Figure 19.7: Percentage pollen diagram of the core from quadrant 'D' of the submerged prehistoric settlement in Sozopol harbour

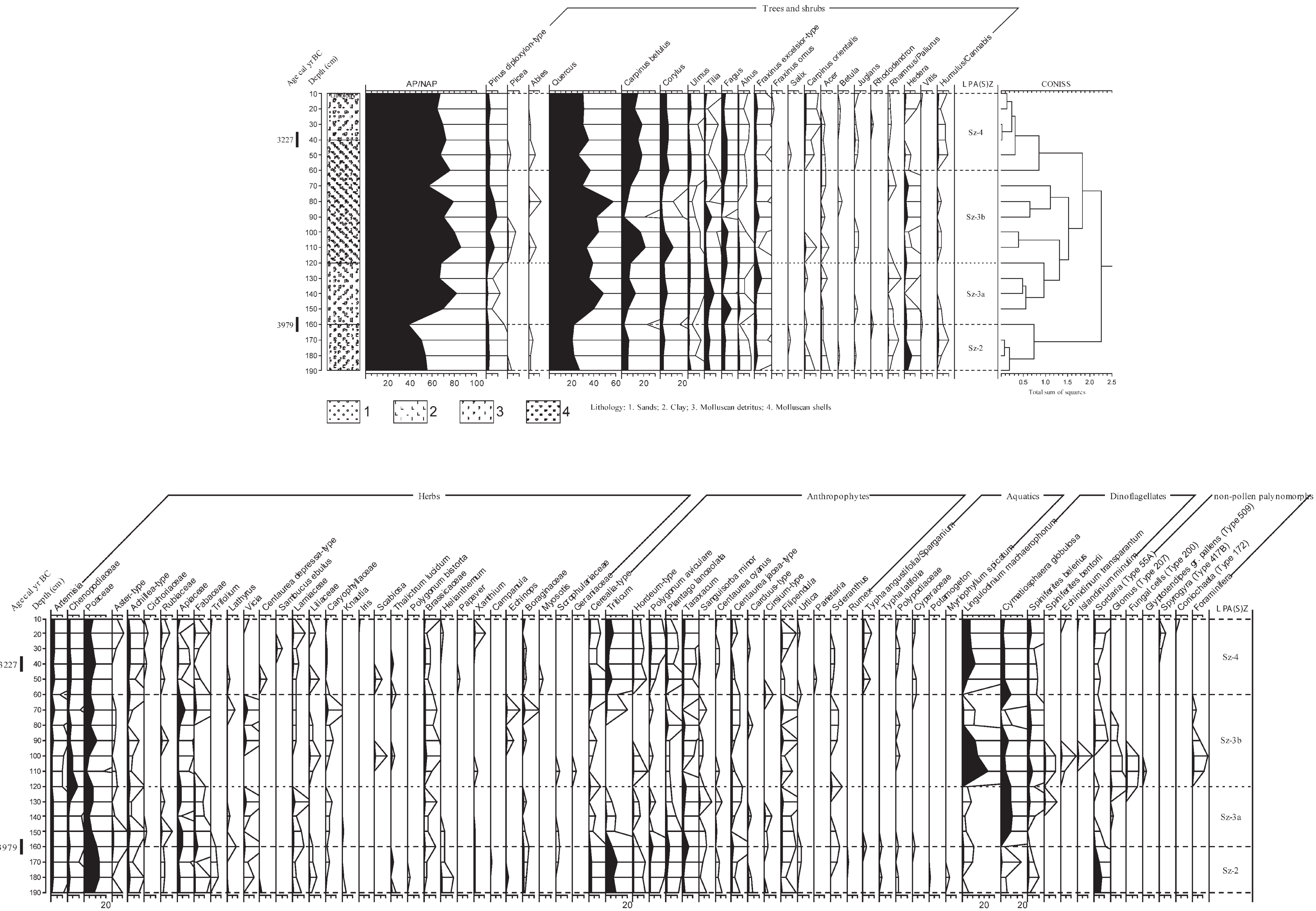


Figure 19.8: Percentage pollen diagram of the core from quadrant 'I' of the submerged prehistoric settlement in Sozopol harbour

of Varna and the keys of Erdtman *et al.* (1961), Beug (1961, 2004), Moore and Webb (1978), Faegri and Iversen (1989), and Reille (1992, 1995). For non-pollen palynomorphs (NPP) the keys of Van Geel and colleagues (Van Hoeve and Hendrikse 1998; Van Geel 2001) were used. The publications of Wall *et al.* (1973), Wall and Dale (1974), Rochon *et al.* (1999), Marret and Zonneveld (2003), and Mudie *et al.* (2001, 2004) were used for the determination of dinoflagellate cysts and acritarchs.

Up to 600 pollen grains of terrestrial plants were counted per sample. The dinoflagellate cysts, other NPP (only for Core 'I'), and charcoal fragments >10 μm (only for Core 'D') were counted on the pollen slides. The percentage values of the pollen taxa were calculated on the basis of AP+NAP sum (arboreal plus non-arboreal plants excluding aquatics, dinoflagellate cysts, and other NPP). The frequency of the micro-charcoal and the dinoflagellate cysts is also presented in percentages on the basis of this pollen sum. Dinoflagellate cysts of *Lingulodinium machaerophorum* in the diagram include forms with long non-clavate and reduced clavate processes.

Based on the most abundant arboreal taxa and anthropogenic indicators, the pollen percentage diagrams (Figs 19.7 and 19.8) were divided into four local pollen assemblage zones (LPAZ Sz-1 to LPAZ Sz-4) with two sub-zones (LPASZ Sz-3a, 3b) to facilitate description and understanding of the vegetation succession. Cluster analysis CONISS (Grimm 1987) was applied for zonation. The zones are numbered from the base upwards and prefixed by the site designation (Sz). The computer programs TILIA v.2.0.b.4 and TGVIEW v.2.0.2. (Grimm 1991, 2004) were used for pollen percentage calculations. For the purposes of comparison, the archaeological chronology for the western Black Sea Coast (Todorova 1986), the chronostratigraphic scheme of the western Black Sea shelf (Shopov 1991), and the Blytt (1876)–Sernander (1908) climatostratigraphic subdivisions of the Holocene were used.

Results

The location of the two cores from the settlements of Sozopol-1 and Sozopol-2 provide excellent possibilities for the correlation of palynological and archaeological data, and for reconstructing the environmental conditions and anthropogenic influence in the area. Important preconditions for such comparisons are AMS radiocarbon dates that fall within the time interval *c.* 4139–3227 cal BC, relating to the Late Eneolithic and Early Bronze Age in conformity with the radiocarbon chronology for Bulgarian prehistory (Görsdorf and Bojadziev 1997).

The four local pollen assemblage zones of Sozopol harbour can be characterized as follows:

*LPAZ Sz-1 (*Quercus–Corylus–Carpinus betulus*)*

This LPAZ is represented only in core 'D'. Pollen data show that mixed-oak forests are widespread because of the high temperature and humidity. The constant, but low, percentage values of *Triticum* and Cerealia-type pollen found in this zone probably belong to wild species, and were not the result of human activity. For example, *Triticum boeoticum* Boiss is recently naturally distributed in the southern Bulgarian Black Sea coast (Kozhuharov 1986). The low impact of human activity is also suggested by the lack of palaeofires inferred from insignificant amounts of micro-charcoal.

*LPAZ Sz-2 (*Quercus–Tilia–Fagus–*Poaceae*–Triticum*)*

This zone is determined in both cores investigated. The palaeoecological record correlates with the Eneolithic period according to the AMS dates of *c.* 4139 and 3979 cal BC from the base of cores 'D' and 'I', respectively. In this zone all arboreal taxa are present with lower frequencies (AP=38.7%) compared to the previous LPAZ Sz-1 of Core 'D' (Table 19.2). The source areas for arboreal pollen were the deciduous forests around the Bay of Sozopol and on the Strandzha Mountains (30 km south of the area investigated), where the environmental conditions during the climatic optimum of the Holocene were extremely favourable for temperate deciduous forests (Filipova-Marinova 2003a). The AP values can be attributed to different species of *Quercus* and partly to *Fagus*, *Ulmus*, *Tilia*, *Fraxinus excelsior*, *Carpinus betulus*, and *Corylus*. The presence of lianas such as *Hedera* and *Humulus* confirms the increase of annual temperatures and moisture. Low pollen percentages of *Pinus diploxylon*-type, *Abies*, and *Picea* in the fossil record reflect long distance transport from the southern Black Sea area.

Cultivated cereals including *Triticum*, weeds

Table 19.2: Correlation of local pollen assemblage zones (LPAZ) and sub-zones (LPASZ) in cores taken from the submerged prehistoric settlements in Sozopol harbour

<table>
<tr><th colspan="2" rowspan="2">Northern European climatostratigraphy (Blytt 1876 – Sernander 1908)</th><th colspan="2" rowspan="2">Chrono-stratigraphic scheme of the western Black Sea shelf (Shopov 1991)</th><th rowspan="2">Archaeological chronology for the western Black Sea coast (Todorova 1986)</th><th colspan="3">Sozopol-I</th><th colspan="2">Sozopol-D</th></tr>
<tr><th>Local PAZ</th><th>Local PASZ</th><th>Pollen assemblages</th><th>Local PAZ</th><th>Pollen assemblages</th></tr>
<tr><td rowspan="6">HOLOCENE</td><td>Subatlantic</td><td rowspan="6">BLACK SEA</td><td>New Black Sea</td><td>Iron Age</td><td colspan="3"></td><td colspan="2" rowspan="4"></td></tr>
<tr><td>Subboreal</td><td rowspan="5">Old Black Sea</td><td>Bronze Age</td><td colspan="2">4</td><td>Quercus, Carpinus betulus, Corylus, Ulmus, Fagus, Triticum</td></tr>
<tr><td rowspan="4">Atlantic</td><td rowspan="2">Transitional Period</td><td rowspan="2">3</td><td>b</td><td>Quercus, Carpinus betulus, Corylus, Tilia, Fagus</td></tr>
<tr><td>a</td><td>Quercus, Tilia, Corylus, Fagus, Carpinus betulus</td></tr>
<tr><td rowspan="2">Eneolithic (Chalcolithic)</td><td colspan="2">2</td><td>Quercus, Tilia, Fagus, Poaceae, Triticum</td><td>2</td><td>Quercus, Corylus, Carpinus betulus, Fagus, Cerealia</td></tr>
<tr><td colspan="3"></td><td>1</td><td>Quercus, Corylus, Carpinus betulus</td></tr>
</table>

(*Centaurea cyanus)*, and ruderals such as *Plantago lanceolata*, *Polygonum aviculare*, *Filipendula*, and *Rumex*, are recorded in this zone, indicating the existence of the Late Eneolithic settlement in the area, and suggest that human activity was the main reason for reduction in the area covered by mixed-oak forests. According to bathymetric measurements (Preisinger *et al.* 2004) (Fig. 19.9A), the Late Eneolithic settlement was located along the Patovska River estuary, on a river terrace 70–80 m wide from east to west with a slight slope of 5–6% to the southwest.

The low percentage values of marine dinoflagellate cysts and the presence of pollen of aquatic species such as *Myriophyllum spicatum* and *Potamogeton* suggest low sea level at this time. The presence of NPP *Spyrogira* (Type 417B) suggests a brackish water environment and stagnant, shallow, open, relatively eutrophic (well-nourished) water at least during the spring. The freshwater–brackish diatom complex established by Ognjanova-Rumenova (1995) in Core 'D' also provides evidence for low water level. The high water table was the main reason that oak piles were used for stabilizing the ground on which the horizontal wooden constructions of the settlement were built (Draganov 1995). Soils near the settlement were moist, rich in humus, and suitable for cultivation. According to Bakels (1978), in the selection of habitation areas, the availability of good arable land near the settlement, called the 'home range', had decisive significance.

The cultivated cereals considered by Behre (1990) as primary anthropogenic indicators are well represented throughout the entire zone and point to intensive agriculture near the settlement. The significant percentages of *Triticum* and *Hordeum*-type pollen are consistent with palaeoethnobotanical data for the Bulgarian Black Sea coast (Behre 1990; Popova and Bozilova 1998; Marinova 2003), suggesting

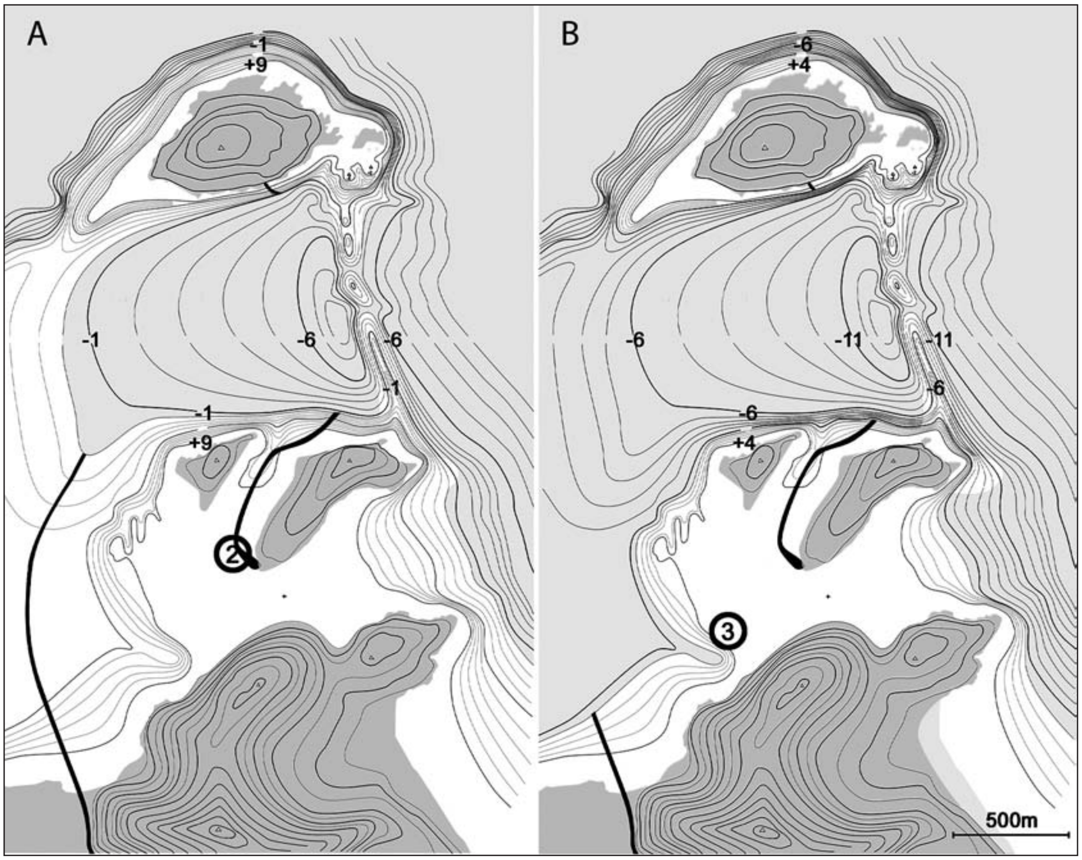


Figure 19.9: Schematic diagram of reconstructed coastlines of the Bay of Sozopol, A: Coastline at c. *4000 cal BC with the location of the Eneolithic settlement (2), and B: Coastline at* c. *2600 cal BC with the location of the Bronze Age settlement (3)*

that *Triticum monococcum*, *T. dicoccum*, *T. aestivum*, and *Hordeum vulgare* were the main crops during the Late Eneolithic. The secondary anthropogenic indicators, including the cereal crop weed *Centaurea cyanus* also indicate farming. The development of farming around the settlement is confirmed by the archaeological finds of vessels and agricultural tools. However, the settlement has yet to be fully investigated, and the tools recovered are not sufficient to determine the extent of farming and agrarian practices.

The low pollen values for weeds could be explained by the manner of harvesting. According to Todorova (1979) stems were cut below the wheatears, and thus weed grains could not fall among the seedcorn. According to Behre (1990) it is the result of dividing weed grains from the seed crop after harvesting, because more weed grains were found in samples from drying ovens than in samples from pits for crop storage.

Palynological data confirm the archaeological information of Todorova (1979) that agriculture was the basis of the Eneolithic economy along the Bulgarian Black Sea coast. The occurrence of ruderals such as *Polygonum aviculare*, *Sanguisorba minor*, and components of wet meadows and pastures such as *Plantago lanceolata*, *Filipendula*, *Carduus*-type, *Cirsium*-type, and *Rumex* indicates pasture formation and stockbreeding (Figs 19.7 and 19.8). *Plantago lanceolata* is considered one of the most reliable secondary anthropogenic indicators and it is widely used to trace the increased activity of prehistoric man, especially stockbreeding and consequently grazing, because of its ability to spread on soils influenced by human activity (Behre 1990; Bottema and Woldring 1990). *Artemisia* and Chenopodiaceae pollen cannot be considered reliable anthropogenic indicators in this coastal area; it is difficult to determine if the pollen of these taxa is natural or a result of human activities because they are components of recent vegetation. The presence of dung indicators such as ascospores of *Sordaria* (Type 55 of NPP) and *Coniochaeta* (Type 172) which, according to Van Geel and colleagues (Van Hoeve and Hendrikse 1998), occur in eutrophic to mesotrophic environments, indicates habitats rich in nitrates. This is confirmed by the presence of *Urtica* pollen, which is characteristic of nitrogen-rich cultivated areas (Figs 19.4 and 19.5).

The peak of microscopic charcoal coincides with anthropogenic indicators and with NPP, indicating a eutrophic to mesotrophic environment. According to Mehringer *et al.* (1977) the presence of micro-charcoal indicates that forest fires in the past could be not only of meteorological but also anthropogenic origin. The maximum occurrence of micro-charcoal at level 60 cm in core 'D', the recovery of charred wood from both submerged settlements, and the charring observed on ceramics suggest that fire was also used for the enlargement of arable areas (Draganov 1998).

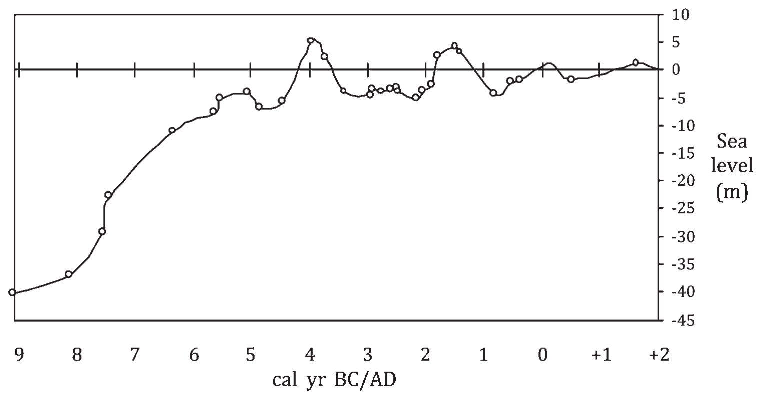
With regard to the occurrence of cultivated trees, it should be noted that the first trace of walnut (*Juglans)* at Sozopol is recorded after *c.* 4139 cal BC (Fig. 19.7). However, the question of whether the presence of this taxon in the pollen diagrams is connected with human culture or is a result of its natural spread along the coast is debatable. The earliest appearance of single pollen grains of *Juglans* along the Bulgarian Black Sea coast during the Holocene is dated at *c.* 9090 cal BC (Filipova-Marinova 2003a), confirming the relict origin of this taxon in the Balkan Peninsula (Velchev 1971; Bottema 1980; Bozilova 1986).

The available AMS dates (*c.* 4139 and 3979 cal BC), palynological and stratigraphic data, as well as the archaeological finds from the submerged prehistoric settlements in Sozopol harbour, provide evidence of cultural development in the area at the final stage of the Late Eneolithic (4100–4000 cal BC).

LPAZ Sz-3

LPAZ Sz-3 is determined in Core 'I' and is divided into two local pollen assemblage sub-zones: LPASZ Sz-3a (*Quercus–Tilia–Corylus–Fagus–Carpinus betulus*) and LPASZ Sz-3b (*Quercus–Carpinus betulus–Corylus–Tilia–Fagus*)

Figure 19.10: Holocene sea-level curve for the Black Sea (Adapted from Filipova-Marinova 2007)



In this zone the AP/NAP ratio suggests enlargement of areas covered by forest vegetation as a result of increased temperature and moisture. Considering the observed peaks of *Quercus*, *Tilia*, *Ulmus*, *Fraxinus excelsior*-type pollen and *Hedera*, this zone most likely represents mixed-oak forest. This must have formed compact communities since the herb pollen taxa show low percentages. A characteristic feature is the significant increase of *Carpinus betulus* together with the decrease of *Quercus*. *Carpinus betulus* is a constituent of mixed-oak forests but the maximum pollen content of 21% in LPASZ Sz-3b suggests that this species probably formed detached monodominant communities in restricted areas as well. The increase of *Carpinus betulus* is due to the migration of this taxon from refugia in the Strandzha Mountains (Filipova-Marinova 2003b). This characteristic vegetation succession and the available AMS radiocarbon date of *c.* 3979 cal BC correlate this zone with the end of the Atlantic.

High percentages of *Carpinus betulus* were also found in other reference sites on the southern Bulgarian Black Sea coast, e.g. Arkutino Lake (Bozilova and Beug 1992), the Veleka River estuary (Filipova-Marinova 2003a), and deep sea Core 544 (Filipova *et al.* 1989). A period of vast spread of *Carpinus betulus* and formation of detached forest belt during the end of Atlantic and the beginning of the Subboreal was also established for the Balkan Mountains (Filipovitch *et al.* 1998). Beech forests, most probably of *Fagus orientalis*, also enlarged their distribution along the humid ravines in the Strandzha Mountains. The presence of *Glomus* (Type 207 of NPP) and fungal cells (Type 200 of NPP) is attributed to an increase in arboreal vegetation.

The sharp decrease of cereal pollen and the gap in cultural development confirms a cultural hiatus of about 500–1000 years between the final stage of the Late Eneolithic and the Early Bronze Age along the Bulgarian Black Sea coast associated with diminishing human population in the area (Todorova 1986). According to Todorova (2002) the Eneolithic cultures in the northeastern part of the Balkan Peninsula had vanished by *c.* 4200 cal BC.

The maximum values of cysts of euryhaline marine dinoflagellates *Lingulodinium machaerophorum*, *Spiniferites belerius*, *Spiniferites ben-*

thorii and *Islandinium minutum*, acritarchs *Cymatiosphaera globulosa*, as well as foraminifera correlate with the domination of planktonic brackish diatom species (Ognjanova-Rumenova *et al*. 1998) and the replacement of clay sediments by more terrigenous ones. Sea level rose and influenced the area during the Black Sea post-Eneolithic transgression (Chepalyga 2002; Filipova-Marinova 2007) (Fig. 19.10). This supports the assumption that the settlements were abandoned. According to the archaeological chronology this zone corresponds with the Transitional Period (post-Eneolithic, proto-Bronze Age) and has been dated by Vajsov (2002) to 4150–3200 cal BC. For the southern part of the Bulgarian Black Sea coast and for the area of submerged prehistoric settlements in Sozopol Harbour it covers the time span 3850–3200 cal BC (Draganov 1998).

LPAZ Sz-4 (*Quercus–Carpinus betulus–Corylus–Ulmus–Fagus–Triticum*)

This zone is represented in core 'I'. The pollen record shows the characteristics of early Subboreal vegetation and is marked by another decline in AP along with re-expansion of cereals and anthropophytic taxa. This change could be considered not only as a succession related to climatic change at the beginning of the Subboreal but also as an indicator of human impact on primeval deciduous forests that involved more significant invasion of *Carpinus betulus* in forest communities. The decrease of AP, mainly of *Quercus*, and the constant presence of *Carpinus orientalis* could be associated with degradation of the mixed-oak forests. Following this, a slight increase of AP is observed despite indicators of human activity. This could be explained by more abundant flowering on the lower branches of trees after some clearance of dense forests. According to Bottema and Woldring (1990) an increase of pollen productivity is possible in such cases.

Conclusions concerning agricultural practice could be drawn from the constant, significant presence of cereals such as *Triticum* and *Hordeum*, and from the occurrence of weeds such as *Centaurea cyanus*. The presence of cultivated cereals indicates human impact, and their significant abundance testifies to the intensity of this impact. According to the palaeoethnobotanical data of Behre (1977), Todorova (1979) and Popova and Bozilova (1998), the main cereals grown along the Bulgarian Black Sea coast during the Bronze Age were *Triticum monococcum*, *Triticum dicoccum*, *Hordeum vulgare*, and *Hordeum vulgare* var. *nudum*. The wide extent of *T. monococcum* during that time was a consequence of its ability to grow on poor soils as well as on very damp soils owing to its well-developed root system.

An increase of secondary anthropogenic indicators such as *Polygonum aviculare*, *Plantago lanceolata*, *Sanguisorba minor*, *Filipendula*, and *Centaurea jacea*-type suggests stockbreeding and enlargement of forest meadows and pastures. According to Ralska-Jasiewiczowa and Van Geel (1998) the presence of pollen of these taxa documents the formation of habitats rich in nitrates. This is confirmed also by the presence of dung indicators such as ascospores of *Sordaria* (Type 55 of NPP) (Van Hoeve and Hendrikse 1998).

The decrease of percentage values of the dinoflagellate cysts *Lingulodinium machaerophorum* and acritarchs *Cymatiospaera globulosa* indicates that after the Transitional Period sea level started to fall making the area around Sozopol Bay habitable again (Fig. 19.9B). The presence of *Typha angustifolia/Sparganium* and Cyperaceae pollen confirms that the Early Bronze Age settlement was constructed on damp soils, and settlers needed to build their dwellings on wooden platforms. Dendrochronological analysis of oak piles from quadrant 'D' and the neighbouring Early Bronze Age settlement of Urdoviza are of great importance (Kuniholm *et al.* 2007). This analysis has shown that mainly oak piles were used. According to Porozhanov (2003) branches of some trees were used for leaf fodder procurement. Archaeological finds from the submerged prehistoric settlements of Sozopol offers the possibility of defining the main characteristics of human activities during the Early Bronze Age, i.e. stockbreeding, use of horses, hunting, and fishing (Angelova and Draganov 2003). Palynological data provide new evidence for the economy of the local tribe around Sozopol showing well-developed agriculture. According to the archaeological chronology, this zone falls within the time span between 3000 and 2800 cal BC (Draganov 1995).

Conclusions

Previous studies of marine and lacustrine sediments have emphasized the governing role of

climate in determining the character of Holocene vegetation on the southern Bulgarian Black Sea coast, dominated by stable mixed-oak forests. The results presented herein provide further evidence for the impact of human activity and sea-level rise in shaping the palaeovegetation of the area.

The study of the submerged prehistoric settlements in Sozopol harbour has provided new evidence about the prehistoric human occupation of the area and has permitted reconstruction of environmental changes and anthropogenic influence on the vegetation. Palynological data reveal two stages of human impact on natural forest vegetation and significant development of agriculture and stockbreeding. *Triticum* and *Hordeum* were the main crops in the area. The low percentages of weeds are connected with the harvesting practice. Micro-charcoal analysis shows that not only felling but also fire was used for clearance of land for agriculture.

AMS radiocarbon determinations provide chronological resolution, dating the cultural periods represented in Sozopol harbour to the final stage of the Late Eneolithic and the second phase of the Early Bronze Age. The decrease in human activity during the intervening period was due to sea-level rise and/or land subsidence.

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20

Was the Black Sea Catastrophically Flooded during the Holocene? – geological evidence and archaeological impacts

Valentina Yanko-Hombach, Peta Mudie and Allan S. Gilbert

Two hypothetical flood scenarios have been proposed for the Black Sea, describing events that may have profoundly affected prehistoric settlement in Eastern Europe and adjacent parts of Asia. The first, a Late Pleistocene 'Great Flood' (Chepalyga 2003, 2007), suggests that the brackish Neoeuxinian Lake in the Black Sea basin was rapidly inundated by Caspian Sea overflow via the Manych Spillway shortly after the Late Glacial Maximum (LGM), c. *17–14 ka BP. The second, an Early Holocene 'Noah's Flood', proposes catastrophic inflow of Mediterranean seawater to a Black Sea freshwater lake at either 7.2 ka BP (Ryan* et al. *1997) or at 8.4 ka BP (Ryan* et al. *2003) when an abrupt sea-level jump accompanied the Laurentide Ice Sheet collapse (Turney and Brown 2007). These hypotheses claim that massive inundations of the Black Sea basin, and ensuing large-scale environmental changes, drastically impacted early societies in coastal areas, forming the basis for Great Flood legends and other folklore, and accelerating the spread of agriculture into Europe. We summarize the geological, palaeontological, palynological, and archaeological evidence for prehistoric lake conditions, vegetation, climate, water salinity, and sea-level change, as well as submerged prehistoric settlements, agricultural development, coastline migration, and hydrological regimes. Comprehensive analysis shows that the Late Glacial inundation in the Black Sea basin was more prolonged and intense than the Holocene one, but there is no underwater archaeological evidence to support any catastrophic submergence of prehistoric Black Sea settlements during the Late Pleistocene or Early Holocene intervals.*

Keywords: archaeological oceanography, megaflood, Neolithic catastrophe, palynology, foraminifera

Introduction

The Black Sea is the world's largest anoxic (oxygen-free) marine basin. Its strongly stratified water column possesses (1) a thin, well-oxygenated surface layer (20–30 m) with low salinity and warm temperatures, (2) a low-oxygen (suboxic) transition layer (30–150 m), and (3) a thick bottom layer of colder, denser, and more saline water lacking oxygen but high in sulphides. Few organisms feed on organic material in its oxygen-starved depths; thus the uniquely favourable underwater environment preserves archaeological material, like shipwrecks, creating the world's largest underwater museum (Ballard *et al.* 2008).

Over geologically recent time, the Black Sea has been intermittently linked to the global ocean through narrow, shallow straits at each end of the Marmara Sea (Fig. 20.1). Its surface area has waxed and waned greatly with climate

Figure 20.1: Map of the Caspian–Black Sea–Mediterranean Corridor showing the topography and major rivers. Dotted yellow lines show the study area of IGCP 521-INQUA 0510 projects. Names of important archaeological sites mentioned in the text are given along with locations of cores 721 and MAR02-45

and sea-level changes. During glacial times of low global sea level, the Black and Marmara seas were isolated from the Mediterranean, becoming inland lakes comparable to the present Caspian Sea (Fig. 20.1). The history of isolation and marine reconnection of the Black Sea, and its impact on regional human occupation and development have been the concern of projects IGCP 521 and INQUA 501 (Yanko-Hombach and Smyntyna 2009). Both projects focus on climate, sea-level change, and coastline migration in the Caspian–Black Sea–Mediterranean corridors during the past 30,000 years, testing hypotheses about catastrophic flooding in the Black Sea. Did abrupt sea-level and salinity changes disperse early cultures, or did gradual and oscillating changes permit people to adapt? Did climate and sea-level dynamics affect the activity of late Palaeolithic hunter-gatherers as well as the later mercantile ventures that moved raw materials and luxury goods between the Mediterranean and hinterlands of Europe and Asia? Catastrophic is defined here as 'very rapid (annual–decadal scale), irreversibly destructive events; any large and disastrous event of great significance; a disaster beyond expectations' (Grishin 2001: 895).

Two abrupt flood scenarios have been proposed for the Black Sea. The first, or Late Pleistocene 'Great Flood' of Chepalyga (2003, 2007) – the CH hypothesis – states that the brackish Neoeuxinian Lake in the Black Sea basin filled rapidly with Caspian Sea brackish overflow via the Manych Spillway shortly after the Late Glacial Maximum, 17–14 ka BP. The second, or Early Holocene 'Noah's Flood' of Ryan *et al.* (1997) and Ryan and Pitman (1998) describes a catastrophic inundation of the Neoeuxinian Lake by inflow of Mediterranean salt water at either 7.2 ka BP (RP1 hypothesis) or 8.4 ka BP (RP2 hypothesis: Ryan *et al.* 2003; Ryan 2007). Turney and Brown (2007) suggest that a jump in sea level was triggered by the Laurentide Ice Sheet collapse (TB hypothesis). These hypotheses propose that the massive inundations of the Black Sea basin and ensuing environmental changes profoundly impacted prehistoric humans in surrounding areas and formed the basis for Great Flood legends. In this chapter, we review the geological, palaeontological, palynological, and archaeological evidence to determine whether it supports an abrupt Holocene flood scenario, or a gradual, fluctuating Holocene sea-level rise (Hiscott *et al.* 2007a, 2007b; Yanko-Hombach 2007a, 2007b) following the megafloods of the Late Pleistocene deglaciation (Chepalyga 2003, 2007).

Previous underwater archaeological studies

Blavatsky (1972) provided the first English language review of underwater archaeological studies in the Black Sea, describing submerged

Graeco-Roman ruins at water depths of 4–8 m near the Azov Sea entrance and in Taman Bay, near Phanagoria (Fig. 20.1). Similar submerged historical archaeological sites were found in the Bug River estuary, Olbia Pontica (Kryzhitskiy *et al.* 1999) in the Dniester estuary, ancient Tyras (Samoilova 1988), and off the southeastern Crimean Peninsula (Bolikhovskaya *et al.* 2004). None of these studies reported any submerged prehistoric settlements.

Dimitrov and Dimitrov (2004: 45–52) reviewed underwater archaeological studies related to a 'Varna Culture' that appeared near the present-day coast of Bulgaria around 5000 BC (assumed to be 'cal BC' but not identified as such in the publication). Drowned settlements in Lakes Durankulak and Varna were dated to 5270 BC (Dimitrov and Dimitrov 2004: 49) by correlation with dated settlements on their shores. They claimed that, 'Before the Flood [about 7600 years ago], Neolithic people inhabited not only today's coast but also that part of the bottom (called the shelf) which was land' (Dimitrov and Dimitrov 2004: 51). So far, however, drowned prehistoric archaeological sites have only been found close to the present Black Sea shore of Cape Shabla north of Varna and in Lake Varna, in water less than 10 m deep (Peev 2009). The Shabla site was indirectly dated to the Eneolithic by correlation with the sea-level curve of Peychev and Peev (2006), and submerged settlements in the coastal Varna–Beloslav Lake were indirectly dated to the Late Eneolithic and Early Bronze Age (Peev 2009: 91).

Coleman and Ballard (2007: 677) reviewed evidence for submerged palaeoshorelines in the southern and western Black Sea and their implications for prehistoric inundation. Despite clusters of Neolithic to Bronze Age sites near the present coastline, evidence of prehistoric occupation at water depths greater than 10 m is restricted to one ceramic plate of debatable Neolithic age from a depth of 90 m off Varna, and photographs of boulders at 90 m depth off Sinop (Fig. 20.1) possibly related to human habitations along a shoreline inundated during the Neolithic, over 8000 years ago (Ballard *et al.* 2001). In fact, underwater artefacts and shipwrecks recovered to date from this region are of historical age (Ward and Ballard 2004; Ward and Horlings 2008). However, Algan *et al.* (2009) found archaeological remnants of a Neolithic culture in Istanbul dating between 8.4 and 7.3 ka BP, indicating shoreline occupation when sea level was 6 m lower than today. These Archaic Fikirtepe pottery sherds are immediately overlain by Early Iron Age artefacts, associated with mollusc shells that were ^{14}C dated to *c.* 3.3 ka BP.

In summary, in spite of decades of searching for submerged prehistoric habitations on the previously subaerially exposed shelves of the Black Sea, there have been no definite finds below a water depth of 10 m, and all reports of Neolithic settlements are based on debatable Early Holocene sea-level estimates.

In this chapter, we outline the geological, palaeontological, and palynological methods used to study Late Glacial to Holocene sea-level and climate changes in the Black Sea. We also summarize the scientific evidence for catastrophic inundation scenarios, the counter-evidence for gradual and oscillating sea-level rise during Late Mesolithic and Neolithic times, and the archaeological impacts implied by the different hypotheses.

Methods

Fieldwork

Geological data presented here were obtained during large-scale surveys of the Black Sea after 1973, using standard modern survey and sampling methods. The surveys accumulated vast databases of stratigraphic, sedimentological, geochemical, and palaeontological information on Pleistocene–Holocene deposits, supported by correlation of bottom sediments with key marine stratotypes (Yanko 1990a) and onshore alluvial and loess sections. Surveying was performed from ships using seismic profiling and seafloor sampling from which hundreds of boreholes, piston, and gravity cores were collected and studied (e.g. Balabanov *et al.* 1981; Shnyukov 1984; Yanko 1990a; Aksu *et al.* 2002a; Hiscott *et al.* 2002; Balabanov 2007, 2009; Ryan 2007). Ultra high-resolution seismic surveys (e.g. Hiscott *et al.* 2007b: 21) also mapped the seafloor (to 50–100 m depth) and sediment cover on a centimetre scale to locate core sites with thick sediment sequences (Fig. 20.2) using a Huntec deep tow system (DTS) boomer profiler. The survey lines were spaced 2–4 km apart, and DTS profiles have a depth resolution of 15–30 cm. During the surveys, seabed surface samples were taken by grab samplers, together with measurements of seawater temperature and salinity to link modern faunas and floras with concurrent oceanographic

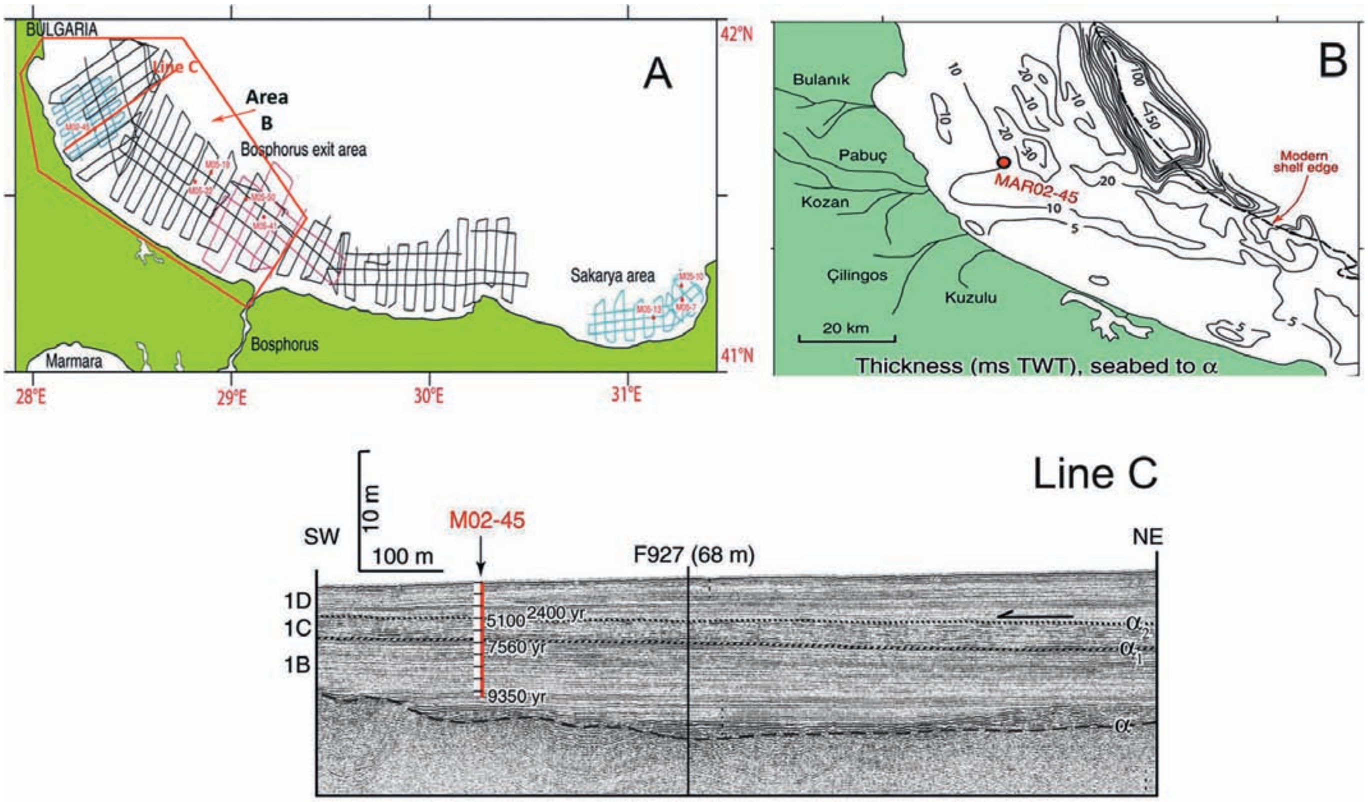

Figure 20.2: Ultra high-resolution seismostratigraphic survey data from the southwestern Black Sea shelf, showing A) line coverage on the southwestern Black Sea Shelf; B) reconstructed sediment thicknesses for the shelf within Area B; and C) a representative profile of sediments along Line C above the a and a-1 unconformities (from Hiscott et al. *2007b); ms TWT = milliseconds of two-way travel time*

conditions. Sediment cores were routinely logged for colour, texture, and structure, presence of shell, wood, and peat. Subsamples were taken for studies of molluscs, foraminifera, coccoliths, ostracods and (rarely) diatoms, and also for palynological studies, including pollen, fern and moss spores, algal spores, fungal remains, and charcoal analysis. Subsamples were also taken for geochemical analysis of oxygen isotope ($\delta^{18}O/^{16}O$) and stable carbon isotope ($\delta^{13}C/^{12}C$) ratios, total carbon, sulphur, and sometimes trace elements, e.g. iron, manganese, magnesium, barium, titanium, and strontium.

Foraminifera

Foraminifera inhabit all marine environments. Planktonic foraminifera live in near-surface water (*c*. 30–100 m depth), and benthic foraminifera live in and just above seabed sediments. Planktonic foraminifera occur in the Aegean and Marmara seas but not in the Black Sea; they are described by Aksu *et al.* (1995a, 2002b) and used to estimate past surface temperature and salinity from oxygen isotopic data. Benthic foraminifera in the Marmara Sea were described by Alavi (1988) and Kaminski *et al.* (2002). Their oxygen and carbon stable isotopes were used (Yanko *et al.* 1999; Aksu *et al.* 2002b) to reconstruct the palaeoceanography of this gateway, including two-way water mass exchange between the Black and Mediterranean seas.

Benthic foraminifera in the Black Sea have been described and supplemented with ecological data (Yanko and Troitskaya 1987; Yanko 1990a, 1990b). In the Black Sea, 101 recent foraminifera species live on the shelf only, with a few living down to 220 m; 86% have a Mediterranean genesis. In the Caspian Sea, 26 mostly endemic species live down to 70 m. The ecostratigraphic alternation in foraminiferal assemblages (Fig. 20.3) mainly reflects responses to isolation and reconnection to the Marmara and Caspian seas as related to sea-level and salinity oscillations (Yanko-Hombach 2007a). The classification of Tchepalyga [Chepalyga] (1984) delineates five palaeobasin salinity categories: fresh <0.5‰, semi-fresh 0.5–5‰, brackish 5–12‰, semi-marine 12–30‰, and marine 30–40‰.

It should be noted that the *UNESCO Practical Salinity Scale* of 1978 (PSS78) is now always used in preference to parts per thousand (‰). The PSS defines salinity in terms of a conductivity ratio, and so is dimensionless. On the PSS open ocean salinity is generally in the range 30–40,

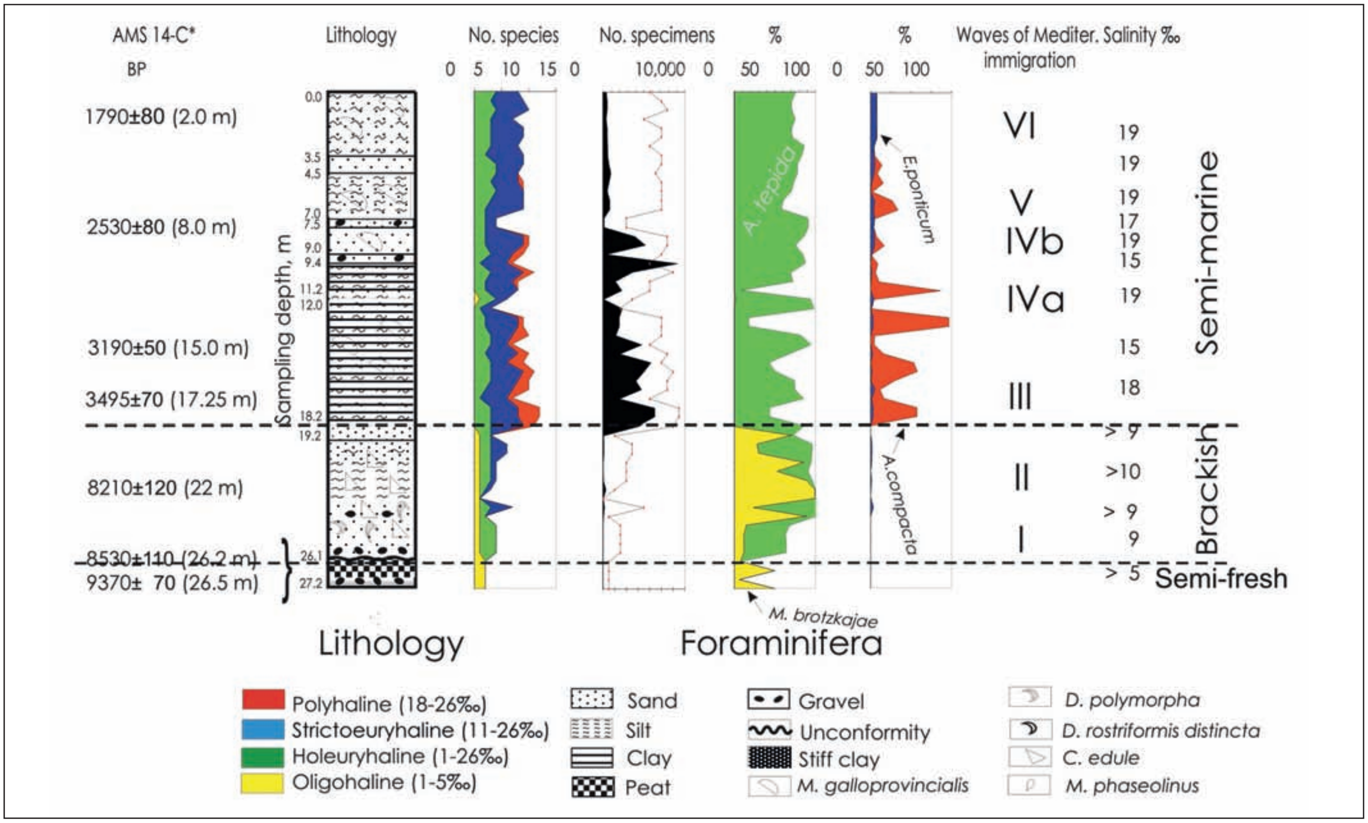

Figure 20.3: Diagrams showing changes in Core 721 recovered at 14.9 m below MSL in Sukhumi Bay (see Fig. 1 for location): (a) lithology, (b) number of species, (c) number of specimens, (e) percentage of dominant foraminiferal species; I–VI waves of Mediterranean immigration (Modified after Yanko-Hombach 2007a; AMS ^{14}C data from Nicholas et al. *2009)*

while brackish seas/waters have salinity in the range 0.5–12. Approximately equivalent values expressed in ppt are 30–50‰ (open sea) and 0.5–30‰ (brackish sea). In this chapter, when salinity is reported without ‰, it refers to the PSS (Mudie *et al.* 2011).

Coccoliths and ostracods

Black Sea shelf sediments younger than *c*. 3.4 ka BP contain low diversity coccolith assemblages (mostly *Emiliania huxleyi*), which live in the surface water (0–20 m) and are used to determine temperature and salinity from their alkenones and DNA. The pre-2.72 ka BP coccolith record is sparse (Jones and Gagnon 1994); consequently, coccoliths cannot be used to reconstruct palaeoceanographic conditions during the Neolithic. Benthic ostracods are relatively abundant back to about 8.5 ka BP on the southwestern Black Sea shelf (Hiscott *et al.* 2007a), and Caspian marker species have been used to fix shelf water salinity at 5 during the Early Holocene (Hiscott *et al.* 2007b).

Palynology

Direct evidence for Neolithic agriculture on formerly subaerially exposed shelves of the Black Sea can come only from palynological studies of cores taken from submarine sediments. Details of such Black Sea cores were described by Mudie *et al.* (2002a, 2002b, 2004, 2007), Atanassova (2005), Filipova-Marinova (2007) and Marret *et al.* (2009), who have established a succession of pollen zones for the Late Pleistocene–Holocene. Some marine pollen zones have been cross-correlated with the pollen zones of surrounding upland areas to reconstruct circum-basin temperature and precipitation conditions during the past 20 ka (Cordova *et al.* 2009). However, correct chemical extraction methods in marine palynology are essential because use of the standard acetolysis method greatly biases dinocyst assemblage composition. Here, we use only reliable data from dinocyst studies that employed the cold HCl and HF extraction method (Mudie *et al.* 2007). We also use dinocysts to estimate sea-surface salinity based on the correlation between percentages of *Spiniferites cruciformis* and salinity estimates using oxygen isotope data from planktonic foraminifera (Mudie *et al.* 2001). Recently, variations in spine length of the dinocyst *Lingulodinium machaerophorum* have been correlated with salinity and temperature at 30 m

water depth (Mertens *et al*. 2009) and used to calculate salinity when temperature is known. *L. machaerophorum* is present throughout most of the Black Sea Holocene sediment section (Marret *et al.* 2009; Verleye *et al.* 2009).

Radiocarbon dating

All radiocarbon dates in this chapter are in uncalibrated years BP unless indicated otherwise as 'cal BP'. Calibrated ages use the IntCal04 (Reimer *et al*. 2004) and Marine04 curves of Hughen *et al.* (2004). We prefer conventional ^{14}C ages because (1) uncertainty surrounds the marine reservoir correction required for Black and Caspian seawater, where living molluscs are much older or younger than the global ocean average of +410 years used for the calibration curves, and (2) controversy and compounding of error are introduced when the early Black Sea lake is classified as 'freshwater' requiring no marine reservoir correction. Abundant data indicate that this lake was brackish with salinity of 5–12 (Nevesskaya 1965; Chepalyga 2002a, 2002b, 2007; Hiscott *et al.* 2007b; Yanko-Hombach 2007a, 2007b).

Results

Evidence for the CH hypothesis

Chepalyga (2003, 2007) first suggested the CH hypothesis and later provided detailed geological, geomorphological, sedimentological, and palaeontological evidence for flooding in the Ponto-Caspian Basin between 17 and 14 ka BP. Palaeoclimate was reconstructed from lake pollen records and oxygen isotopes from molluscs of the flooded Ponto-Caspian basin. The CH hypothesis describes a Late Pleistocene Great Flood during the Caspian Early Khvalynian stage, when water level in the basin rose 180–190 m, and a cascade of Eurasian Basins (the Vorukashah Sea) extended from the Aral to Aegean seas, connected via the former Uzboy and Manych–Azov–Kerch spillways as well as the current Bosporus and Dardanelles straits (Fig. 20.4).

The cascade inundated *c.* 1.5 million km^2 with a volume of *c.* 700,000 km^3 of semi-fresh to brackish water (about twice the present annual river inflow to the Black Sea), leaving traces on coastal plains, river valleys (megafloods), watersheds (thermokarst lakes), and slopes (solifluction) (Chepalyga 2007: 119). Yanko-Hombach *et al.* (2007) summarized evidence for the CH scenario and provided micropalaeontological data; Dolukhanov and Arslanov (2007) reviewed the archaeological and palaeoecological evidence, including pollen records from lakes north of the Black Sea. Vast amounts of meltwater originated from the Scandinavian ice sheet, river megafloods, and permafrost melting; lower evapotranspiration rates during the colder Late Glacial period were also postulated (Fig. 20.5). The Late Khvalynian water level rose by 50 m (Fig. 20.6), and outburst flooding from Altai Mountain ice-dammed lakes may also have contributed to early Holocene drainage into the Aral and Caspian seas (e.g. Reuther *et al.* 2006).

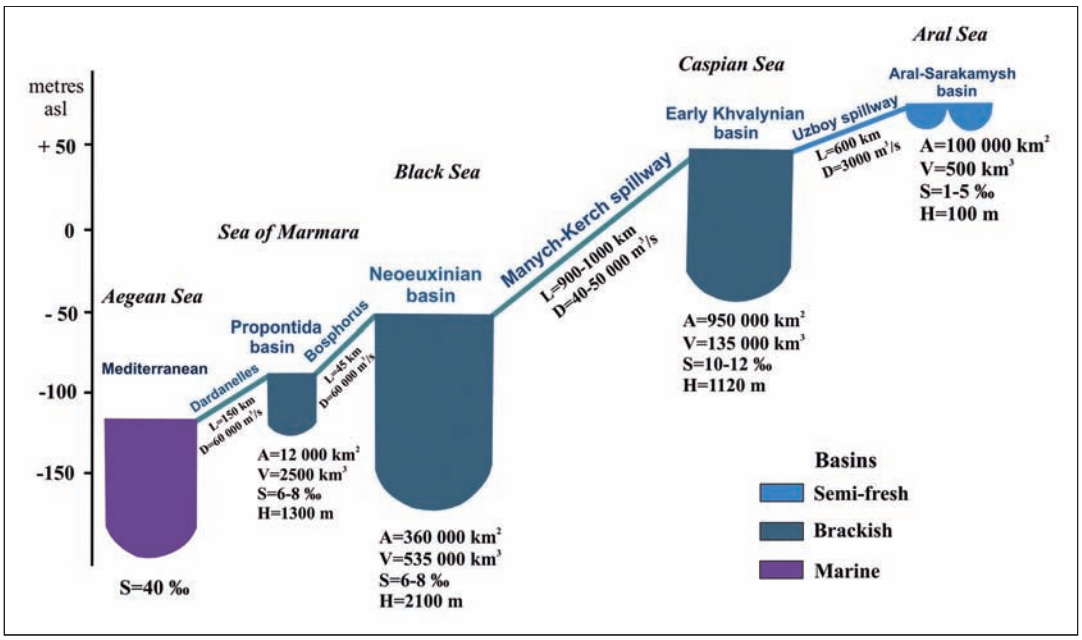

Figure 20.4: Cascade of Ponto-Caspian Great Flood basins (after Chepalyga 2002). A = basin surface area, V = volume, S = salinity, H = water depth, L = length of connected straits, D = speed of water current in the straits

The Early Khvalynian basin could not retain all the inflowing water, so excess was discharged through the Manych–Azov–Kerch Spillway into the Late Neoeuxinian Lake (Fig. 20.6) with an estimated speed of about 1000 km^3 per year – three times faster than the present river discharge. The water influx raised the Late Neoeuxinian Lake level 60–70 m, and then spilled into the Sea of Marmara. The drastic changes in sea level and coastal inundation (up to 10–20 km/year) submerged extensive floodplain areas, possibly forcing migrations of Palaeolithic people into 'safe areas' and stimulating cultural advances. This flow pattern was traced by following the distribution of 'chocolate clays' (cf. Ryan *et al.* 2003), loams and sands of 20–30 m thickness, containing endemic Caspian molluscs *Didacna, Monodacna, Adacna, Hypanis*, and foraminifera *Mayerella brotzkajae* and *Ammonia caspica* (Yanko-Hombach *et al.* 2007: fig. 5) across all the basins from the Caspian Sea to the Dardanelles Strait.

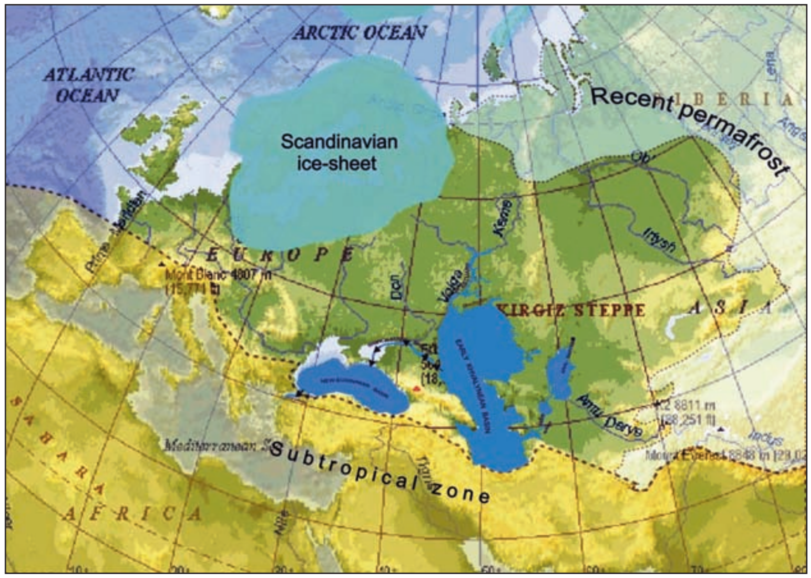

Figure 20.5: Area inundated by the Great Flood events (after Chepalyga 2007). Dotted line marks the northern boundary of the present subtropical climate zone

Evidence for the RP hypothesis

The RP flood hypothesis was introduced by Ryan *et al.* (1997) as an abrupt drowning of the Black Sea shelf; shortly thereafter, it appeared in a book (Ryan and Pitman 1998) that was heavily criticized by archaeologists for its speculations on 'sensational issues, such as Noah's Flood, the origin of the Sumerians, and the beginnings of agriculture and civilization' (Özdoğan 2007: 652).

Figure 20.6: Map showing the sequence of Ponto-Caspian Great Flood basins (after Chepalyga 2007)

The general survey areas on the Black Sea's northern shelf were identified, but these seminal catastrophic flood publications gave no details on the methods used. The book mentioned a CHIRP (Concentrated High Intensity Radar Pulse) system that penetrated to a sub-bottom depth of 10 m. Later, Ryan *et al.* (2007: fig. 1) published high-resolution profiles of the outer shelf with a seismogram of a linear sandy ridge and riverbed fill at 65–70 m depth on the Danube shelf. Seven low-resolution cores about 1.25 m long formed the basis for the RP hypothesis. No details of the cores were given aside from the well-preserved euryhaline marine molluscs (*Cardium edule*, *Mytilaster lineatus*, *Mytilus galloprovincialis*, *Hydrobia ventrosa*, and *Abra ovata*) in soft sediment just above a stiff basal clay layer. AMS radiocarbon ages for the first three of the above molluscs yielded a conventional radiocarbon age of 7100±100 BP (OS-2323) for the shell layer in water depths of 49–123 m below MSL. Ryan *et al.* (1997: 122–3) extrapolated the age of the stiff clay from dredged shells of *Dreissena rostriformis* that they called freshwater 'Caspian' molluscs, although Nevesskaya (1965) indicated that the species tolerates salinities up to 12‰, as do co-existing molluscs (*Monodacna caspia*), ostracods (*Leptocythere bacuana*), and foraminifera (*Mayerella brotzkajae*) (Shornikov 1972; Yanko and Gramova 1990). These *D. rostriformis* shells came from shelf sediments below a gravel layer, and bleached fragments yielded ages from 14,700±65 (OS-2360) to 10,400±55 BP (OS-2358), though in other cores (Major *et al.* 2006) the ages were as young as 8250±35 BP (Major 2002). The stiff clay contained plant material, fluvial gastropods (*Viviparus viviparus*), desiccation cracks, and other features suggesting alluvial to coastal marsh environments.

Ryan *et al.* (1997: 123) then correlated their low-resolution cores with short gravity cores from deeper-water areas studied by Jones and Gagnon (1994), and they extracted dinoflagellate, foraminiferal, and diatom data from studies of Wall and Dale (1974), Meriç and Sakınç (1990), and Shimkus *et al.* (1973) to compile a figure (Ryan *et al.* 1997: fig. 3) apparently showing an abrupt transition from 'freshwater' to euryhaline marine faunas and floras. Despite the low resolution of their geophysical surveys and palaeontological studies, and extrapolation of results from incomplete early work on dino-flagellate cysts (dinocysts), benthic foraminifera and diatoms, they considered that their findings complemented descriptions of emergent land surfaces with loess soils, littoral deposits, and beach terraces in shelf formations spanning 17.78–9.66 ka BP at depths of 93–122 m. Ryan *et al.* (1997: 119) outlined the first [RP1] catastrophic flood hypothesis (Fig. 20.7) as follows:

> 'During latest Quaternary glaciation, the Black Sea became a giant freshwater lake. The surface of this lake drew down to levels more than 100 m below its outlet. When the Mediterranean rose to the Bosporus sill at 7,150 yr BP, salt water poured through this spillway to refill the lake and submerge, catastrophically, more than 100,000 km^2 of exposed continental shelf. The permanent drowning of a vast terrestrial landscape may possibly have accelerated the

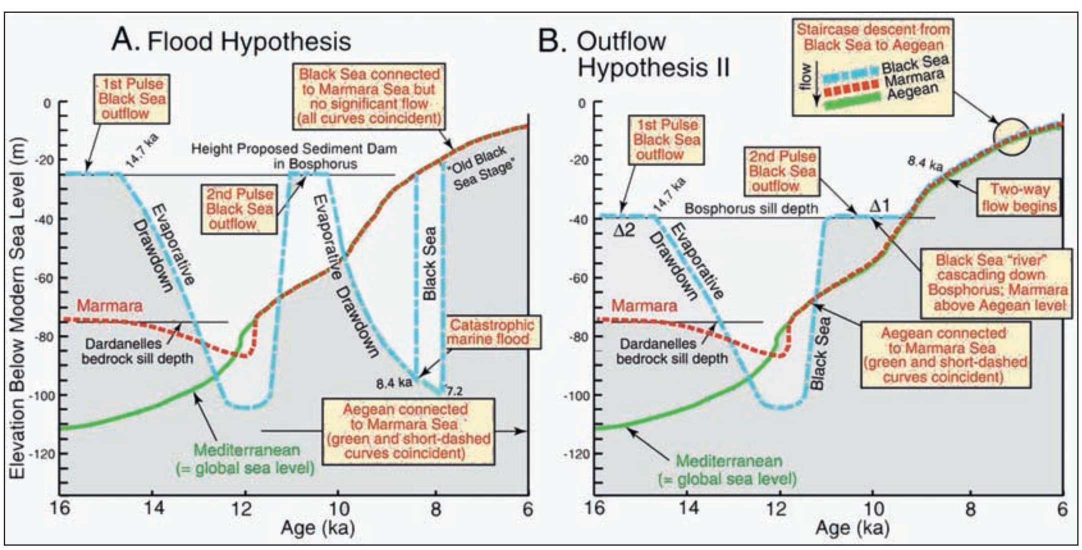

Figure 20.7: Left: RP catastrophic flood hypothesis, with two Holocene evaporative draw-downs of a fresh-water Black Sea 'lake' terminated by a deluge of seawater at c. *7.2 ka BP (RP1) or 8.4 ka BP (RP2). Right: Hiscott* et al. *(2007a, 2007b) gradual flood hypothesis with strong but declining Black Sea outflow since* c. *11 ka BP, resulting in sapropel deposition in Marmara and Aegean seas and gradually increasing inflow of Mediterranean water over the southwestern Black Sea shelf after* c. *9.5 ka BP*

dispersal of early neolithic foragers and farmers into the interior of Europe at that time.'

Subsequently, Major *et al.* (2002) examined longer (2–7 m) sediment cores from the upper Romanian continental slope that provided continuous 20,000-year, high-resolution records of sediments, clay mineralogy, carbonate, and stable isotope geochemistry of bulk carbonate (including reworked biogenic and detrital material). The RP1 hypothesis was then adjusted to include a possible gradual marine inundation like that recorded for the Marmara Sea (Çağatay *et al.* 2000; Aksu *et al.* 2002a) beginning *c.* 12.8 ka BP. Major *et al.* (2002: 32), explained the apparent delay in the introduction of marine fauna and flora into the Black Sea until 7.1 ka BP as the time required for gradual (not catastrophic) salinization of the water to a level suitable for these organisms.

Ryan *et al.* (2003: 549) then reviewed older low-resolution and younger higher resolution seismic data from 1997 and, using Major's geochemical data, determined that:

> 'Although the Black Sea witnessed at least eight marine flooding events in the past three million years, it is not possible from the available data to argue that these were catastrophic floods analogous to the Holocene event.'

They noted that sediments deposited between 8.4 and 7.1 ka BP showed a transition from brackish to marine water over about 1000 years (Ryan *et al.* 2003: 546). Although the term 'transition' was now used instead of 'abrupt', they still concluded that well-preserved dune features at water depths of 50–90 m were rapidly drowned between 8.5 and 8.4 ka BP, and cited other evidence for abrupt flooding such as absence of coastal onlap in the soft surface sediment unit. They also used onshore pollen studies from north of the Black Sea to infer that the climate was arid until after initial salinization (presumably 7.1 ka BP).

Major *et al.* (2006) and Ryan (2007) then focused on new geochemical data in the latest refinement, RP2, of the catastrophic flood hypothesis. Major *et al.* (2006) presented oxygen and strontium isotopic and strontium/calcium ratio measurements of mollusc and ostracod shells obtained from 27 cores in three areas of the northern shelf. They concluded that the Black Sea filled and flowed into the Marmara Sea twice between *c.* 15 and 13 ka BP, with a final shift to marine values in strontium and oxygen isotope ratios at 8.3 ka BP corresponding to connection with the global ocean earlier than previously suggested by appearance of euryhaline fauna and onset of sapropel formation in deep water. These abrupt (100–300 year) changes in strontium and oxygen isotope ratio were compatible with a Black Sea volume increase between an Early Neolithic lowstand at 80 m below present MSL and a Bosporus Strait spill-over depth of 35 m, but uncertainties in the dating, stratigraphy, and presence of older reworked material made it impossible to distinguish between a 'flood' and 'gradual inflow' scenario (Major *et al.* 2006: 2041). Nonetheless, Ryan (2007: 63) persisted with the view that rapid flooding best accounted for the evidence but accepted an earlier timing (8.4 ka BP) for the start of his Holocene flooding event, proposing that two lowstands (-120 m at 13.4–11 ka BP and -95 m at 10–8.4 ka BP) and two catastrophic transgressions (from -120 to -30 m at 11–10 ka BP; and from -95 to -30 m at 8.4 ka BP) occurred. The second transgression was called the Great Flood.

The RP1 hypothesis received support from *The French Research Institute for Exploration of the Sea* (IFREMER) seismic surveys, which apparently indicated well-preserved drowned beaches, sand dunes, and soils (Lericolais *et al.* 2007a: 449), while Bahr *et al.* (2008) detected abrupt temperature and water chemistry changes in Black Sea ostracods over a 100-year interval during Early Neolithic time.

A refinement of the RP2 catastrophic flood hypothesis was introduced by Turney and Brown (2007), who recycled Major's published mollusc ^{14}C ages into a model based on 'high precision dating of the marine flooding of the freshwater Black Sea' (Turney and Brown 2007: 2040). The TB catastrophic flood model removed corrections for a hardwater or marine reservoir effect from the so-called 'freshwater' molluscs living in the Black Sea before 7940±75 BP, and assumed a mean ΔR of 50±63 years for the oldest Black Sea marine mollusc in order to narrow the age of the Early Holocene inundation. A Bayesian model was constructed for these age-adjusted data (Turney and Brown 2007: 2038) to show that the Mediterranean infilling of the Black Sea occurred between 8350 and 8230 cal BP. Turney and Brown connected this marine incursion with the *c.* 8.2 cal ka BP global cooling event associated with final collapse of the Laurentide Ice Sheet and outflow of floodwater from Lake Agassiz (Teller 2002; Clarke *et al.* 2004); they claimed this event

was possibly accompanied by a 1.4 m sea-level rise.

Evidence for the gradual sea-level rise hypothesis

Ross and Degens (1974) first suggested a gradual reconnection and transition from isolated freshwater Black Sea lake to stagnant marine conditions, beginning *c.* 9 ka BP. Aksu *et al.* (1995b) also deduced a gradual sea-level rise and reconnection of the Black, Marmara, and Aegean seas from the occurrence of sapropel layers in Aegean Sea cores; sapropel formation requires sustained Black Sea outflow to stratify the ocean and increase terrigenous organic matter content. The start of this Black Sea outflow was dated to 9.6 ka BP, setting a minimum age for Holocene breaching of the Bosporus Strait at 40 m below MSL. More detailed work on the origin and timing of sapropel deposition in the Black, Marmara, and Aegean seas followed (Aksu *et al.* 2002a, 2002c). Thereafter, Hiscott *et al.* (2007a, 2007b) focused on the Late Pleistocene to Holocene history of the shelf north of the Bosporus Strait, where high-resolution seismostratigraphic surveys (Fig. 20.2) revealed a thick layer of soft sediment above the stiff clay and gravel – reflector α (= surface of seismic wave reflector) – that prohibited recovery of long cores on the northern shelf by Ryan *et al.* (1997, 2003) and on the southern shelf by Ballard *et al.* (2000, 2008). The study by Hiscott *et al.* (2007b) (Fig. 20.8) showed that, at a present water depth of 70 m on the southwestern shelf, 10 m of mud overlying the reflector α transgressive unconformity record an uninterrupted sequence of sedimentation during the Neolithic and Early Bronze Age from 9.3 to 4.5 ka BP. Fourteen AMS radiocarbon ages from molluscs in the reference core, MAR02-45, constrain the chronology of sedimentation and allow accurate calculation of rates of environmental change. Seven ages for in-place specimens of the 'semi-fresh' species *Dreissena polymorpha*, *D. rostriformis*, *Truncatella subcylindrica*, *Monodacna pontica, Didacna* spp., and *Theodoxus* spp. provided a very high-resolution record for the sediment unit C representing the palaeoenvironment from *c.* 9.3 to 7.6 ka BP, i.e. the time interval of the hypothetical RP and TB catastrophic sea-level transgression.

The sedimentology of Core MAR02-45 and neighbouring cores (Hiscott *et al.* 2007b: 25–7) shows that at 9.3 ka BP the central and outer shelf were not subaerially exposed but were already covered by semi-fresh water to a depth greater than 20 m. Filipova-Marinova (2007: 467) also reports that from *c.* 9.95 to 8.35 ka BP lagoon–estuarine sediments with *D. polymorpha* molluscs occurred in the Veleka River valley on the present Bulgarian coast, at depths of 25–40 m below MSL, showing that the entire western shelf was inundated by the start of the Neolithic. Ostracods from Core MAR02-45 indicate slightly brackish conditions: salinity of at least 5‰, and possibly as high as 7–13‰ (Marret *et al.* 2009).

About 4 m of these brackish-water, silty mud sediments in Core MAR02-45 were continuously deposited at an average rate of 36 cm/century from 9.3 to 7.56 ka BP. During this time, benthic foraminifera and dinocyst assemblages indicate a

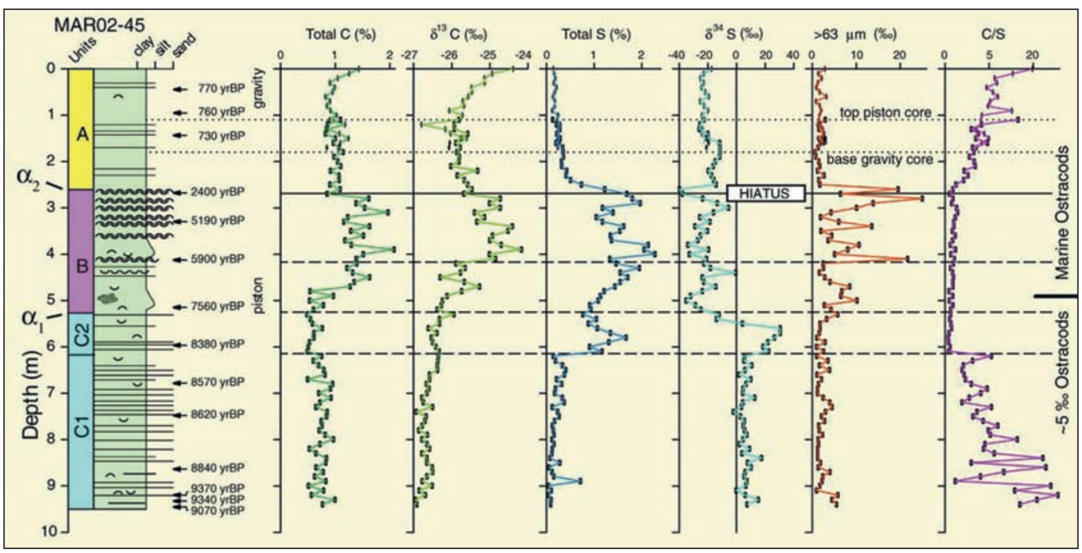

Figure 20.8: Core MAR02-45 sedimentology and geochemistry. A = colour-mottled/banded, burrowed mud with silt laminae and rare shells; B = alternating mud and shelly mud (mussels) with high sulphur and negative $\delta^{34}S$; C = colour-banded mud with graded silt and very fine sand beds, and rapid changes in TS and $\delta^{34}S$ in the upper part (C2)

low but rising salinity and steady decrease in the carbon:sulphur ratio, as expected for inflow of seawater that has more sulphur than river water. From 8.4 to 7.6 ka BP (subunit C2, Fig. 20.8), a temporary increase in $\delta^{34}S$ (ratio of seawater sulphate to bacteria-reduced sulphides) marks the first sustained inflow of Mediterranean water from *c.* 8.3 to 7.9 ka BP. Subsequently, sulphur was precipitated, indicating establishment of the modern stratification with inflowing saline Aegean bottom seawater and outflowing low-salinity Black Sea surface water.

After this gradual establishment of the modern two-way circulation system through the Bosporus Strait over about 410 years, sedimentation slowed to 8.5 cm/century from 7.56–4 ka BP (Hiscott *et al.* 2007b: 28–9) commensurate with a gradual increase in surface-dwelling Mediterranean dinocysts, and slightly more rapid increases in bottom-dwelling Mediterranean ostracods and foraminifera that live today in salinities of 17–19‰ (Yanko 1990a; Yanko-Hombach 2007a). After 4 ka BP, the present-day low-salinity marine flora and fauna were established, with increases in sedimentation rate and terrigenous organic carbon influx marking landscape changes accompanying Bronze Age to Graeco-Roman farming and land clearance (Mudie *et al.* 2002a, 2007; Cordova *et al.* 2009). Overall, there was a gradual rise in water level over the shelf after the last evaporative drawdown of the Black Sea during the cold dry interval from about 13–11 ka BP and following the major outflow of water from *c.* 11–9.5 ka BP (Fig. 20.7).

The high-resolution chronology established for Core MAR02-45 (Mudie *et al.* 2007) provided the first decadal-scale resolution of vegetation records and allowed calculation of annual influx rates for pollen and spores on the Black Sea shelf (Fig. 20.9) in contrast to earlier studies (e.g. Mudie *et al.* 2002a; Atanassova 2005; Filipova-Marinova 2007) reporting relative abundances and concentrations. By 9.3 ka BP, pollen influxes from moisture-demanding forest trees like deciduous oak (*Quercus cerris*), lime (*Tilia*), beech (*Fagus*) and elm (*Ulmus*), together with shade ferns, aquatics, and swamp plants indicate year-round precipitation of >600–1000 mm, and warm winters are indicated by *Pistacia* (that requires winter temperatures of 5°C or more). These palynological data record conditions on the shelf and immediately adjoining coasts; they contradict the proposed early Holocene dry conditions essential to the RP and TB scenarios involving lake level drawdown to 110 m below present MSL. High-resolution shelf pollen data also provide direct archives of Neolithic and Eneolithic land

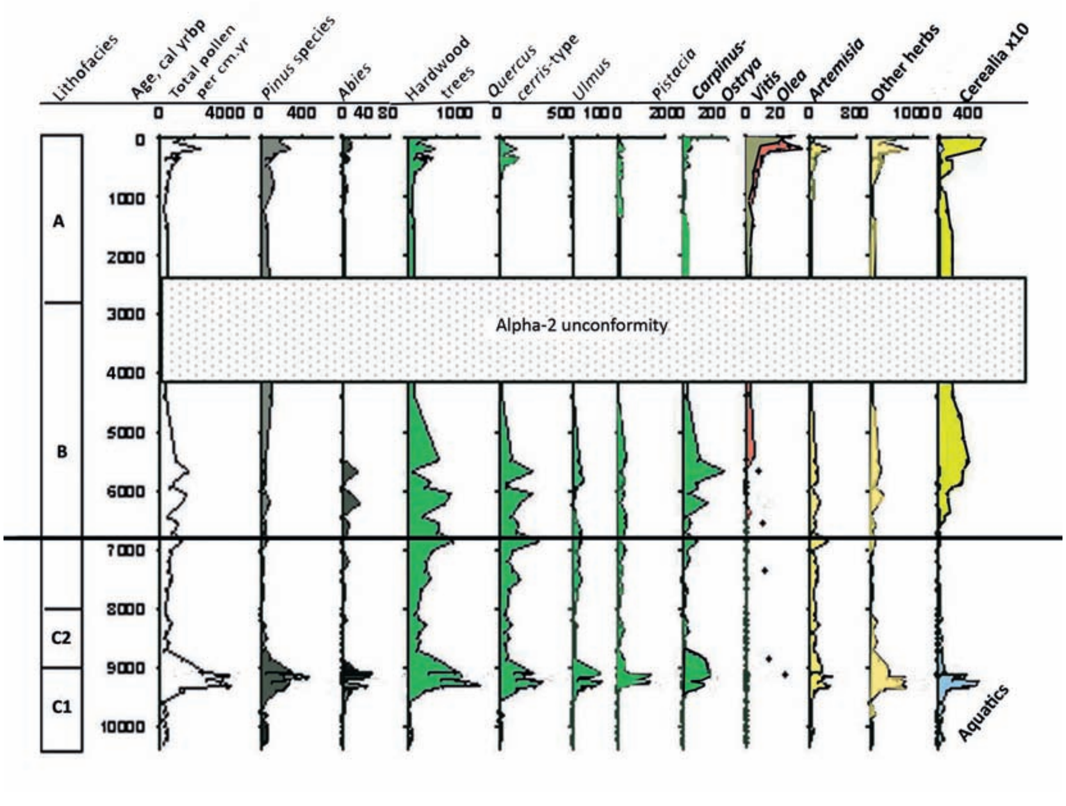

Figure 20.9: Pollen influx diagram for Core MAR02-45, showing selected tree pollen species that indicate temperature and moisture conditions, and markers of agricultural/horticultural activity: Cerealia, Vitis vinifera *(grapes) and* Olea *(olives). Influx scale is in grains per cm² yr⁻¹*

use and show no evidence of grain production (Cerealia pollen) before *c.* 6500 cal BP, when the first cereal pollen appears in the Bulgarian coastal lakes (Marinova and Atanassova 2006; Filipova-Marinova 2007; Filipova-Marinova and Angelova 2008). Sparseness of charcoal particles and fungal spores indicating animal herding further suggest neither Neolithic/Eneolithic grassland burning nor animal husbandry on the exposed Early Holocene shelf.

Evidence for oscillating sea levels

Evidence for oscillating sea levels during the gradual rise of Black Sea water is presented in many publications (Tchepalyga [Chepalyga] 1984; Voskoboynikov *et al.* 1985; Yanko 1990a, 1990b; Yanko and Gramova 1990; Shilik 1997; Chepalyga 2002a, 2002b; Balabanov 2007, 2009; and summarized in English by Yanko-Hombach 2007a, 2007b, and Yanko-Hombach *et al.* 2007). The oscillating scenarios state that Holocene water-level transformation was neither gradual nor catastrophic but fluctuated from a low point around -100 m from 27–18 ka BP to -20 m at *c.* 10 ka BP. Afterwards, sea level remained above -40 m and fluctuated within 20 m of present MSL. Holocene sea level showed an overall increase, in agreement with the 'gradual' hypothesis, but oscillating up to its present level. The re-colonization of the Black Sea by Mediterranean marine immigrants began *c.* 9 ka BP and became prominent at 7.2 ka BP. This re-colonization occurred over six oscillating transgression–regression stages (Fig. 20.3).

Discussion

Ryan's rebuttal of the gradual sea-level rise model

Despite substantial high-resolution data documenting the refilling and outflow of the Black Sea to the Aegean by *c.* 11 ka BP, and gradual but oscillating sea-level rise during the Early Holocene, Ryan (2007: 64–5) still rejected the evidence for a Black Sea surface rising with global sea level via an early connection through the Bosporus Strait or as outflow via Izmit Bay, Sapanca Lake, and Sakarya Valley (Brinkmann 1976; Kerey *et al.* 2004; Yanko-Hombach *et al.* 2004) at a lower sill depth of 85 m below MSL. Ryan (2007: 66–7, 72–3) pinned major importance on oxygen isotopic data that appeared to record low salinity in an isolated lake although the evidence was from mixed sediments containing reworked lithic carbon and shell fragments. Ryan (2007: 71–2) also emphasized earlier interpretations of freshwater dinocyst assemblages, apparently not recognizing the biasing impact of the oxidative acetolysis laboratory processing method (see Methods section, and Marret *et al.* 2009), and he contested the validity of the pre-2002 seismostratigraphic evidence for a gradual transgression of the southwestern Black Sea shelf, and post-flooding deposition of bedforms beneath inflowing Mediterranean waters (Ryan 2007: 78–9). It is now clear, however, that the southwestern shelf records continuous transgressive coastal onlap after 9.3 ka BP, and bedforms can change simply because of shifts in the rim currents scouring the outer shelves of the Black Sea (Hiscott *et al.* 2007b; Flood *et al.* 2009). Hence, the evidence supporting the gradual sea-level rise model remains intact and is further supported by new high-resolution studies of Giosan *et al*. (2009).

Evidence for drowned windblown dunes

The claim of Lericolais *et al.* (2007b: 177) that the Black Sea shoreline was at -100 m until about 8.5 ka BP is not based on direct dating of the dune-like features at that depth but comes from CHIRP sonar profile correlation with a shallower core site >100 m distant, where the Holocene section is only *c.* 0.7 m thick. CHIRP sonar profiles have an optimal vertical resolution of 10–15 cm; at best, this condensed core thickness means that the age of the dune top could be 9.5 ka or older. In contrast, the Holocene cores of Hiscott *et al.* (2007) and Giosan *et al.* (2009) are 10–45 m thick and have permitted direct dating of the first transgressive deposits, showing that the shoreline was above -40 m at 8.8 ka BP. These thicker deposits provide details of the reconnection process, including direct palynological proxy-data for local vegetation and a relatively warm, moist climate. In contrast, Lericolais *et al.* (2007a, 2007b, 2009) repeatedly claim evidence for a very dry Early Holocene climate based on pollen records from their shelf cores, but none of these have been published.

Was there really a catastrophic Black Sea flood that changed human prehistory?

General agreement now exists among researchers that megafloods occurred from 17–14 ka BP, inundating extensive areas of the Black Sea–Caspian region. Chepalyga (2007: 143) argues for a late Palaeolithic upland migration

and a stimulus toward the development of water transport technology, as suggested by Mesolithic rock drawings in Gobustan of 9–8 ka BP (Dzhafarzade 1973). Stanko (2007: 377–82) recorded Mesolithic population increase in the lower Dniester valley from 14–12 ka BP, but no evidence of catastrophes for the time span of 14–6 ka BP. Dolukhanov *et al.* (2009: 4–5) describe coastal landscapes for the northern Black Sea and pollen data from Ukraine indicating likely effects on Palaeolithic groups due to the extermination of mammoth and woolly rhino by 18 ka BP and replacement by bison (Stanko 2007: 376). Not until *c.* 12 ka BP, however, is there evidence of a southward migration of people into the wetlands of the Danube, Dniester and Dnieper estuaries, where waterfowl hunting may have been important. Although it is reasonable to suggest that there may have been settlements on an emergent shelf (Dolukhanov *et al.* 2009: 4), no underwater sites or animal bones have yet been recovered, and the earliest evidence of regional farming dates to the Late Chernomorian stage (7–4 ka BP) for numerous sites in the upper Dniester basin and scattered sites near the Azov Sea (Dolukhanov *et al.* 2009). Özdoğan (1999) emphasized indirect evidence that the Holocene transgression coincided with human migration from the Mediterranean area into the Pontic Lowland, not the other way as flood avoidance would imply.

Whether or not a hypothetical Neolithic catastrophic inundation gave rise to the story of Noah's Flood, one can say only that, so far, no scientific data support a Holocene flood rate of 40 m per century – the best estimate of Ryan *et al.* (2003) for the drowning of sand dunes on the Danube shelf from -90 to -50 m between 8.5–8.4 ka BP. Turney and Brown's (2007) idea that an abrupt sea-level transgression at *c.* 8350–8230 cal BP was possibly associated with a 1.4 m sea-level rise during the final Laurentide Ice Sheet collapse is not supported by the model of Clarke *et al.* (2004: 404), who estimated a sea-level rise of 8–41 cm, and wrote:

> 'The effect on sea level cannot have been large. The maximum effect ... has a sea level equivalent of 0.41 m but for all reference models the released volume from above sea level was considerably less than the available volume, over a period of *c.* 100 years.'

A 40 m sea-level rise over 100 years would surely have discouraged settlement on the continental shelves, and there is still neither archaeological evidence for human habitation on the outer shelves nor marine palynological evidence of Neolithic land clearance or agriculture before the Eneolithic (Chalcolithic), *c.* 6 ka BP. Abundant geological survey evidence and sediment cores from the Turkish shelf north of the Bosporus (Hiscott *et al.* 2007a, 2007b, 2008) show the area was already flooded to -20 m by 9.3 ka BP, by which time the Danube shelf dunes in deeper water on the Romanian shelf would also have been submerged. Hence, the drowned dune data cannot be used as reliable evidence for catastrophic inundation of Neolithic occupation sites.

Advocates of the catastrophic flood hypothesis have also invoked an arid Early Holocene climate for the Black Sea but have failed to use pollen data from marine cores (Mudie *et al.* 2001, 2002a, 2007) that show the Early Holocene climate in the southern Black and eastern Marmara seas was warm, wet, and supporting mesic forest trees by 9.5 ka BP. Further, quantitative palynological data (Mudie *et al.* 2001; Marret *et al.* 2009; Verleye *et al.* 2009) establish that Wall and Dale's Early Holocene *Spiniferites cruciformi*s dinocyst flora indicates brackish conditions of 5–11, not the fresh water suggested in the earliest studies (Wall and Dale 1974).

Overall, there is a conspicuous lack of archaeological and archaeobotanical evidence to support the contention that Neolithic people occupied the shelves of the Black Sea much beyond the present shoreline. Anthony (2007: 345) concluded that even if the Black Sea rose catastrophically over the North Pontic plain from 7600–7300 cal BP, only an estimated 100–150 foraging bands of 50–75 people would have been impacted, and there is no certain evidence for a sudden change in human behaviour at this time. Likewise, Bailey (2007: 515) commented that '… proposed links between a dramatic rise in the Black Sea and spread of agriculture across Europe … are unhelpful', and recommended more refined documentation of Holocene changes in the Black Sea. Mesic Early Holocene conditions during cooler and wetter times than now must be incorporated into new palaeoenvironmental models involving human habitation of the Black Sea shelves. Direct evidence from high-resolution marine palynological cores (Mudie *et al.* 2002b, 2007) suggests a marshy and mosquito-infested region subject to periodic river flooding. This might provide good hunting and fishing but

poor conditions for settled farming because of brackish water and soils prone to salinization and waterlogging; these problems still restrict coastal farming today.

To summarize, we cite two leading archaeologists to whose memory we dedicate this chapter: Pavel M. Dolukhanov (1937–2009) and Vladimir N. Stanko (1937–2008):

> 'Existing archaeological data strongly support a scenario of gradual environmental changes in the northern Pontic area during the Late Pleistocene and Holocene. Reliable evidence suggests that the changes in subsistence and cultural dynamics resulted from a combination of socio-economic and environmental factors, fluctuations in precipitation being the most important among the latter.' (Dolukhanov and Shilik 2007: 314)

> 'The emergence of farming was a gradual process deeply rooted in the local traditions, and in no way was it connected with a catastrophic flooding of the coastal area.' (Stanko 2007: 376).

Conclusions

Geological and palaeontological data records of Late Pleistocene inundations in the Black Sea–Caspian region indicate extensive megaflooding far greater in scale than the Holocene. Archaeological evidence for catastrophic impact on Palaeolithic foragers is controversial. As yet, no underwater Palaeolithic or Mesolithic settlements have been found.

The salinity of the Neoeuxinian Lake was brackish and non-potable, like that of the modern Caspian Sea, placing farming at risk of salinization. Temporary settlement on delta interfluves may have occurred, but the only evidence of early watercraft comes from rock art in the Caspian area.

When Late Pleistocene flooding ended at about 9.5 ka BP, water level was near the -40 m sill depth of the Bosporus Strait. Inflowing Mediterranean water raised the level gradually and in an oscillating manner up to about 20 m below present MSL by 7.56 ka BP, concomitantly raising salinity from brackish to semi-marine (16–22). Exposed shelf areas along the coastline would have been swampy and prone to salinization, not favourable for arboriculture, agriculture, or animal husbandry. No substantiated geological evidence for catastrophic Holocene flooding and no archaeological or palynological evidence for prehistoric occupation of the Black Sea shelves exists near the modern coastline in water depths greater than 10 m. The TB hypothesis of a catastrophic Black Sea flood overrunning shoreline Neolithic settlements at *c.* 8.4 ka BP is neither supported by calculations of global sea-level rise of 8–41 cm (less than a normal tsunami) nor by a Bayesian model for ^{14}C dating of molluscs from 8.4–8.2 ka BP due to unresolved questions about appropriate reservoir corrections for brackish water palaeoenvironments.

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21

Underwater Investigations at the Early Sites of Aspros and Nissi Beach on Cyprus

Albert J. Ammerman, Duncan Howitt-Marshall, Jonathan Benjamin and Tim Turnbull

This chapter presents the results of underwater reconnaissance work carried out in front of two early sites on Cyprus. In addition, it is the story of how a land-based project decided to get its feet wet. As late as 2003, there was only one good candidate for a site (Aetokremnos) dating to the pre-Neolithic on the island. In 2004, reconnaissance work on land made it possible to identify several new early sites (including Aspros and Nissi Beach) located on coastal formations of aeolianite. Previously, the archaeologist on Cyprus had essentially ignored the aeolianite that now holds one of the keys to the study of the origins of seafaring in the Eastern Mediterranean. Given the low position of sea levels prior to 10,000 years ago, there is a good chance that what one finds on land today is just the tip of the iceberg. At Aspros in the summer of 2007, the aim was to trace one of the early sites out into the water. For the first time on Cyprus, dive site C at the foot of a submerged cliff on the north bank of the Aspros River yielded a set of chipped stone pieces in the water. Much, of course, remains to be done at Aspros and Nissi Beach. The work undertaken so far represents just the first step toward learning more about early sites in submerged contexts on Cyprus.

Keywords: underwater archaeology, Cyprus, Younger Dryas, Aspros, Nissi Beach

Introduction

The aim of this chapter is to report on the underwater work recently done in front of two early sites on Cyprus: Aspros and Nissi Beach (Fig. 21.1). They both occur on coastal formations of aeolianite, the name for an old sand dune that has become lithified over the course of geological time. The two sites were identified by means of reconnaissance work on land in 2004 (Ammerman *et al.* 2006). The spatial distribution of the lithic scatters at each site (on land today) covers an area the size of a football field, and the chipped stone tools found on the surface in both cases date to the end of the Last Glaciation (*c.* 10,000 to 12,000 years ago). Previously, there was a lack of known prehistoric sites on the island dating back to this period of time. In section 2, more will be said about the reasons for initiating the fieldwork, the development of the project over the years, and the decision that we eventually made to get our feet wet.

By way of introduction, it is worth adding that since Cyprus is one of the very few large, offshore islands in the Eastern Mediterranean, the sites of Aspros and Nissi Beach now play a leading role in the study of the origins of seafaring in this part of the world (Ammerman 2010). In the case of Aspros the underwater reconnaissance work was conducted in 2007, and it led to the recovery of several pieces of chipped stone (Ammerman *et al.* 2008: 4–9). For the first time on Cyprus, a set of early lithics was recovered from a submerged context. This chapter has three main sections. After this brief introduction, the first section

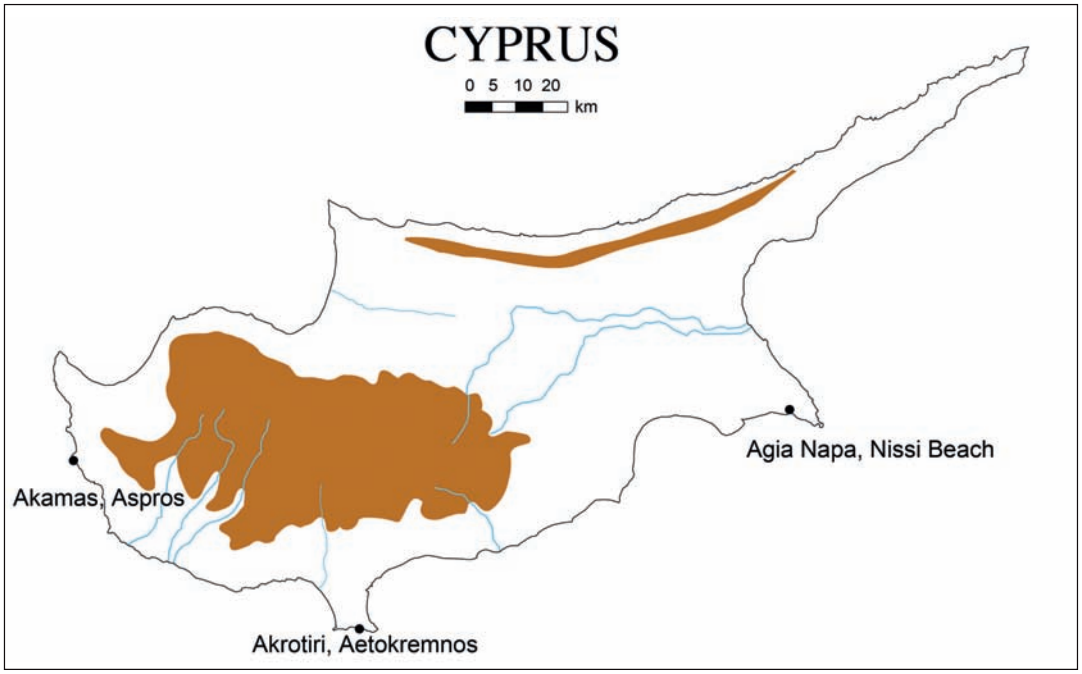

Figure 21.1: The location of the early sites in Cyprus. Underwater surveys have been carried out off the sites of Aspros and Nissi Beach

will describe the underwater reconnaissance work that was done in front of Aspros. The purpose of the second section – in light of the positive results at Aspros – is to step back and trace the steps in the evolution of our work over a span of six years (2004–2009). The purpose of the third section is to comment on where we stand today and what needs to be done next on Cyprus. In effect, this chapter is the story of a land-based project that, in time, came to realize – not without trepidation – that it had to take the plunge.

The underwater reconnaissance work at Aspros

As part of the environmental studies that Jay Noller carried out on land at Aspros in 2006, he drew a map (Fig. 21.2) showing where the shoreline would have stood at two times in the past: 6000 and 12,000 years ago (Ammerman *et al.* 2007: fig. 3). It is well known that sea level was lower at the end of the Last Glaciation (e.g. Lambeck and Chappell 2001; Peltier 2002; Lambeck *et al.* 2004). Given the bathymetry in front of Aspros, there would have been an area of dry land that was just over 1 km wide at the latter time. The implication for the archaeologist is that what one finds on land is probably just the tip of the iceberg. Thus, the logical thing to do would be to explore the submerged area just off the coast. Of course, this is something that is much easier said than done. To our knowledge, no one on Cyprus has ever tried to trace an early site out into the water before.

To start with, trying to find small pieces of chipped stone on the seabed at a depth of 10–12 m may pose a challenge even for a person with training in underwater archaeology. In practical terms, one can cover only a small area with the kind of close attention that is called for, and the success or failure of the work may well depend upon selecting the right place to look. The costs and the logistical aspects of doing underwater archaeology are not insignificant. And one could add to this list the possibility that the marine transgression at the end of the Last Glaciation

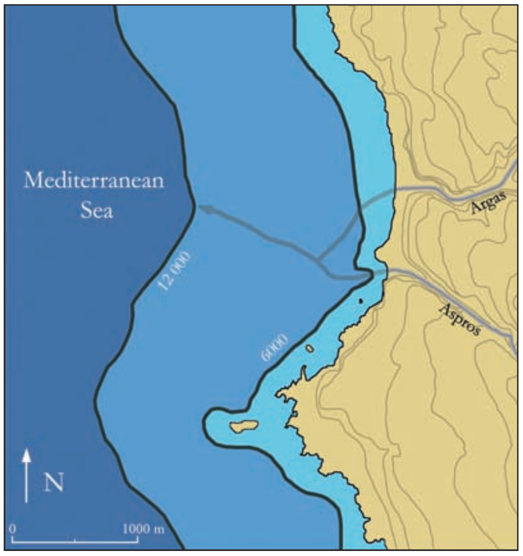

Figure 21.2: The environmental context of the Aspros site. Palaeoshoreline ages in cal yr BP

may have been less than friendly when it comes to the survival of an early site. On the other hand, such an investigation was something that we had to do, if we wished to obtain a more balanced and comprehensive picture of what was happening at Aspros. Fortunately, we can report that the underwater work in front of the site yielded positive results.

The fieldwork had two main aims: (1) the recovery of pieces of chipped stone from the seabed at a certain depth and distance from the coast (to show that this could be done), and (2) the acquisition of a better knowledge of what the submerged area in front of Aspros looks like in terms of its relief, its geology, and its potential for future reconnaissance work of this kind.

At this point, it is worth adding that some preliminary work had already been done in June of 2006 in order to find out whether or not underwater archaeology was really feasible at Aspros. Toward this end, Jonathan Benjamin, then a graduate student at the University of Edinburgh, came out to Cyprus and joined us at Aspros for a week. He explored the shallow area close to the shoreline by means of snorkeling; he also made two SCUBA dives from a boat off the coast to a depth of 15 m (Benjamin 2006). Although this trial work did not lead directly to the recovery of lithic material in the water, it was a valuable step in providing local knowledge on the submerged area in front of the site. In June of 2006, we also had the chance to put differential GPS equipment on a boat with a depth finder and to use it to make transects just to the west of the site (Ammerman *et al*. 2007: 8–13). One of the transects ran along the course of the Aspros River itself, and one was made on the river's south side. The three others covered the area to the north of the river. Thus, there was the chance to generate a good overall picture of the submerged relief just off the coast.

Unfortunately, Benjamin had other commitments that summer. Turnbull now took the lead in coordinating the work in the water and its documentation. The lead underwater archaeologist was Duncan Howitt-Marshall, a graduate student at the University of Cambridge. A total of thirteen dives were made at Aspros in the period between June 26 and July 4 (Ammerman *et al.* 2008: 4–9).

The basic approach was to concentrate on the north side of the Aspros River: the area to the west of the site on land. All of the dives except a deeper one (down to *c*. 28 m) were made at depths in the range of 6–15 m and at a distance of 50–200 m from the shoreline today. Dive sites of limited size were selected, and initial survey of the bottom was carried out with the aim of finding good potential places for closer inspection and the collection of pieces of chipped stone. Two or three divers working together as a lithic-recovery team were then assigned to such a place with the task of collecting the lithics on the bottom, while an over-watch dive master kept an eye on the progress of the work and documented the dive site. The divers soon learned from experience that the best way to search for small pieces of chipped stone on the seabed was by using a gentle hand fanning motion over the substrate to reveal underlying rock fragments and lithic pieces hidden beneath particles of coarse and fine sediments.

On the north bank of the Aspros River out to a depth of 15 m, one finds a westerly-directed extension of the geological formations of aeolianite and marine sandstone observed on land (Ammerman *et al.* 2007: 7). At a distance of *c*. 150 m from the present shoreline, there is a well-defined vertical 'step' or drop in the bedrock of the kind seen in outcrops of aeolianite just to the east of Aspros. The wave-cut terrace produced by the marine transgression is deeply eroded and scoured because of the soft character of the aeolianite in some places. Since it is less well lithified with depth, this kind of rock has a tendency to become undercut if it is exposed in a vertical face. Hence, the seabed immediately in front of Aspros takes the form of elevated spurs where the rock is more resistant to wave action and depressions and crevices where the bedrock is less resistant in character. Because of the 'case hardening' of the aeolianite at the valley edge (Ammerman *et al*. 2007: 7), the cliff on the north bank of the Aspros River, as seen for instance at dive site C, is more resistant to the marine transgression. In fact, this is why we chose it as one of our dive sites and, not surprisingly, it produced the best results of the 2007 season.

The first three dive sites that we selected all produced at least one lithic artefact. In each case, only part of the bottom was examined intensively in the limited time that was available (Ammerman *et al.* 2008: 7). The work at dive site A produced two intact ground stone tools. It is worth adding that pieces of ground stone have not been recovered from the land surface at Aspros, so the underwater reconnaissance work is adding something new here.

Dive site B occurs at a distance of approximately 135 m from the present shoreline, in a place where a long spur of the aeolianite terminates and there is a pronounced drop in the relief just to the west. In this case, the coverage reached a maximum depth of 13 m. At the start of the survey, the team made two dives at this site, and the work led to the recovery of two pieces of chipped stone.

Dive site C is clearly the one that produced the most interesting results. It occurs right on the north bank of the Aspros River. Here one finds a steep cliff some 4 m tall – much like the cliff that is seen on land at the south edge of the Aspros site (Ammerman *et al.* 2006: fig. 4). We examined the surface of the aeolianite at the top of the cliff and also the area at its foot (Fig. 21.3), where the land surface once stood in a position slightly above the riverbed of the Aspros. In all, the team made six dives in this place, working at depths of 9–12 m. At several different points along the foot of the cliff, the divers were able to recover chipped stone pieces that have survived in a fairly good state of preservation (Figs 21.4 and 21.5). On the bottom, one finds a coarse sediment that is rippled into ridges oriented at right angles to the easterly-directed wave action. Small gravels, pebbles, and even the occasional piece of sub-angular rock are sequestered in the intervening furrows. At the top of the cliff, the rocky surface is dominated by a low algal growth; one encounters here and there either small depressions filled with sediment or else pockets of rock occasionally overlain with mats of dead seagrass. On the whole, visibility is more limited in the upper part of dive site C. For this reason, less effort was put into the coverage there. In all, a total of 38 pieces of chipped stone were recovered at dive site C.

The size of the lithic sample at dive site C is, of course, small, and there may be some biases when it comes to the sizes and the shapes of the lithics that the divers were able to see in the water. The important thing at this stage of the research is that the fieldwork did lead to the recovery of lithics in a submerged context and that the material is made with the same reduction technology found on land at Aspros. Pieces classified as cultural in the underwater sample by Carole McCartney, our lithic specialist, were clearly produced by conchoidal fracture, though all of them have been altered to some extent by the mechanical action of waves and abrasion from sand. Because of this, the artefacts are highly fragmentary, and formal tools are more easily recognized than informal utilized implements,

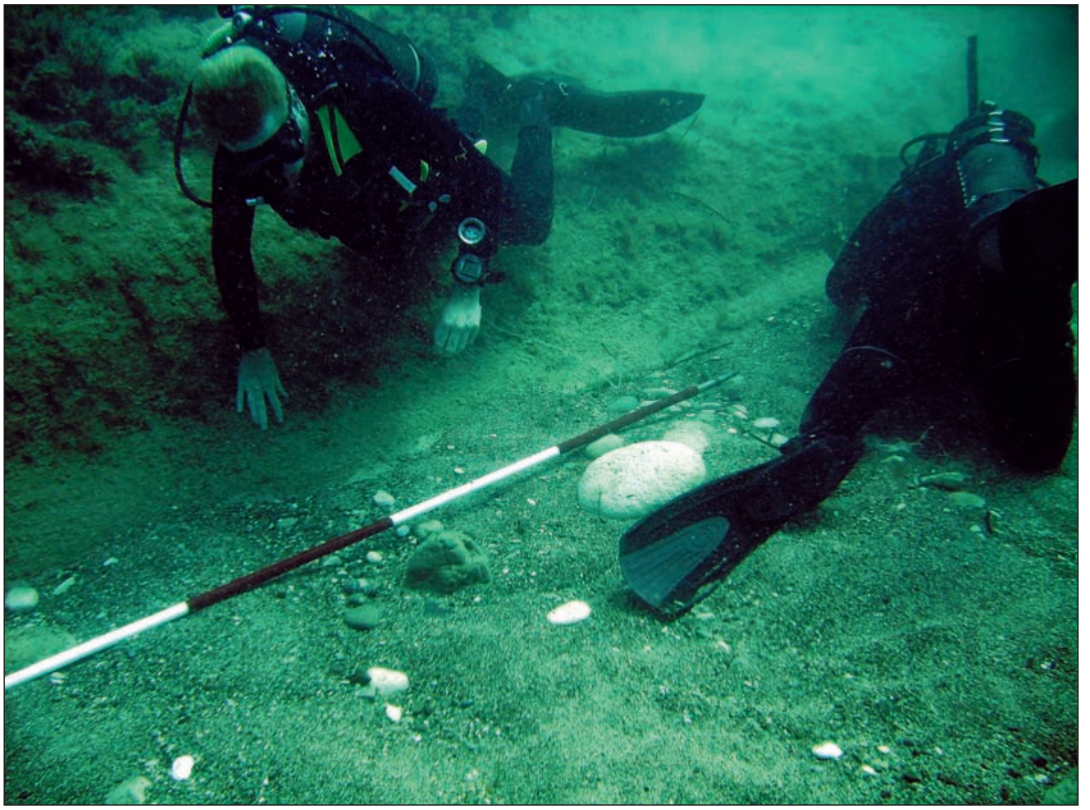

Figure 21.3: Work in progress at dive site C in front of Aspros (Photo: A. J. Ammerman 2007)

Figure 21.4: Example of lithics from dive site C off Aspros (Photo: A. J. Ammerman)

which are poorly attested. Cores are absent from the underwater sample, which is dominated by debris and equal numbers of unworked blanks (mainly chips) and tools. The pieces classified as tools include: one backed piece, one notch, two perforators, four pieces with miscellaneous retouch, and two utilized flakes (Ammerman *et al*. 2008: 19).

What is now called for at dive site C is the more active extraction of the chipped stone pieces from the sediment by using appropriate mechanical means, so that a larger sample of lithics as well as more diagnostic tools can be recovered (as suggested by Anders Fischer at the EAA meeting held in September 2009). The real challenge now is to assemble the right team with the right equipment on Cyprus and to obtain sufficient funding for the next cycle of more intensive underwater work at Aspros. In retrospect, it is perhaps not all that surprising that we were able to recover early lithics on the seabed where we did, since dive site C is close to a place on the landscape where two rivers, the Aspros and the Avgas, once came together (see Fig. 21.2).

Evolution of the research

The purpose of this section is to place the underwater work at the two sites in its wider context. Doing underwater archaeology was the last thing that the first author had on his mind in the autumn of 2003 when he went out to Cyprus as a Fulbright Senior Scholar with the task of finding the missing pre-Neolithic sites on the island.

Indeed, it was far from clear in 2003 whether or not the fieldwork (on land) would be all that productive. Previously, others had carried out surveys in search of pre-Neolithic sites on Cyprus. But they had come away empty-handed. It was entirely possible that this would be our fate as well. Many of the friends and colleagues of the first author thought that he was not making a wise decision in going out to Cyprus. At the time, the only good candidate for a pre-Neolithic site on the island was Aetokremnos on the Akrotiri Peninsula (Simmons 1999). However, this site (a collapsed rockshelter found by a British schoolboy and not by an archaeologist) was the subject of much debate in the literature (e.g. Binford 2000; Ammerman and Noller 2005). And, in 2003, the conventional wisdom still had it that coastal foragers were reluctant seafarers and that pre-Neolithic sites were hard to find on the Mediterranean islands (e.g. Cherry 1990). The new early sites that would soon come to light on Cyprus (Ammerman *et al*. 2006, 2007) and Crete (Strasser *et al*. 2010) together with the ones recently documented on several islands of the Aegean would now show that these were old and misguided ideas (Ammerman 2010).

As it turns out, what had been missing all

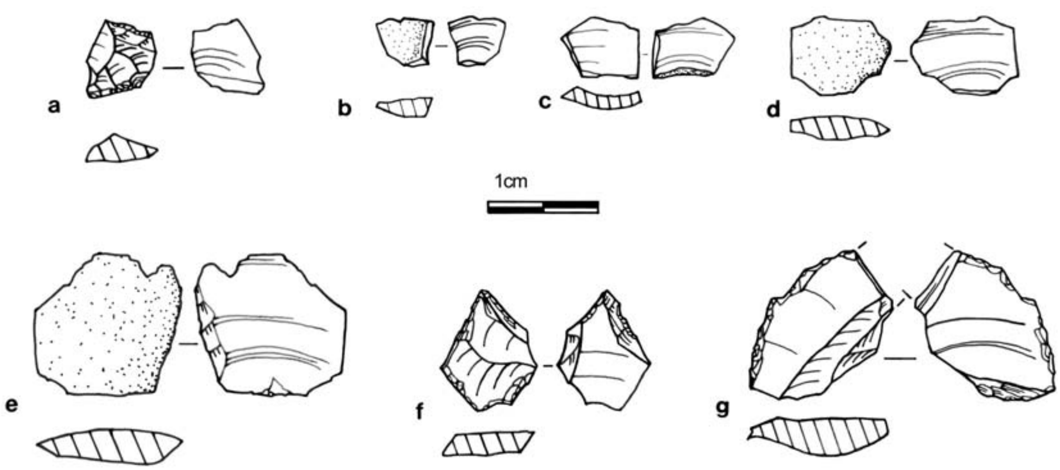

Figure 21.5: Characteristic lithic specimens from Aspros site C (2007 Survey): backed piece (a), chips (b–c), core-opening flakes (d–e), perforator (f), retouched flake (g) (Drawings: Tom Davis)

along on Cyprus were not the early sites but the right approach to finding them. If one looked on the formations of aeolianite around the coast, which archaeologists had essentially ignored before, the sites were sitting there on the land surface – patiently waiting to be discovered. In retrospect, the problem of the missing pre-Neolithic sites on Cyprus was due, in many ways, to the success of the multi-period survey itself. Embedded in the sampling strategy of such surveys, as they were commonly done in the 1970s and 1980s, was an agricultural agenda, which discouraged the archaeologist from covering the aeolianite.

What sparked the first author's interest in going out to Cyprus was the new evidence from the excavations at Shillourokambos and Mylouthkia: namely, the new knowledge that the Neolithic package on the mainland had already crossed the sea by 8000 cal BC (e.g. Guilaine and Le Brun 2003; Peltenburg and Wasse 2004). For such an early and rapid transition to the Neolithic to have taken place, it was reasonable to think that there must have been a prelude to it: that is, coastal foragers from the mainland were making seasonal trips to the island before that time. By taking a new approach to reconnaissance work on the island (Ammerman *et al.* 2006), we soon had the chance to find Nissi Beach, Aspros, Alimman, and several other new early sites on the island.

The new sites, as mentioned before, are all located on coastal formations of aeolianite. In planning the reconnaissance work, we specifically set out to cover such places on the landscape since the aeolianite offers favourable conditions for the visibility of small pieces of chipped stone on the ground. At first glance, this part of the landscape appears to be a rather inhospitable one. However, if one takes a closer look, the aeolianite offers a good place for making a short-term campsite. There is little or no vegetation to clear, and the land surface is invariably a dry one. In addition, the local configuration of the bedrock can provide in some cases what amounts to built-in, Stone Age 'furniture' (see Ammerman *et al.* 2008: fig. 7).

The study of the lithic material recovered at the two new early sites was done by Carole McCartney who had previously examined the chipped stone assemblage at Aetokremnos. What one is dealing with in each of the three cases is a reduction technology that is quite different from the blade-oriented one normally found at sites of Pre-Pottery Neolithic (PPN) B age on Cyprus. Instead, the lithic tradition at all three sites is a more expedient one; it involves the production of small flakes from local pebbles and cobbles. In addition, the types of stone tools recovered at Aspros, Nissi Beach, and Aetokremnos are, for the most part, much the same (Ammerman *et al.* 2006: 11–17; Ammerman *et al.* 2008: 17–26).

From the excavations at Aetokremnos, there are eight ^{14}C dates on samples of charcoal whose calibrated ages (Fig. 21.6) date to the time between *c.* 11,000 and 9500 cal BC (Ammerman *et al.* 2007: fig. 9). Thus, it was now possible to put forward the working hypothesis that the advent of seafaring (on a recurrent basis and not just an accidental voyage or a rare case of rafting) in the Eastern Mediterranean goes back to the Younger Dryas (Ammerman *et al.* 2006: 18). Working independently on a review article in the same year, Broodbank (2006: 208–11) came up with the same idea: that is, the connection between the Younger Dryas and the birth of seafaring in the Mediterranean world. Previously, the evidence for pre-Neolithic sites on offshore islands in the Eastern Mediterranean was so thin that no one was in a position to advance this hypothesis.

The next steps in the work at the two sites were taken in June of 2006 when Benjamin came out to Cyprus to conduct his underwater feasibility study. At that time, only 18 months had elapsed since the discovery of Aspros in December of 2004. In other words, we were already starting to think about getting our feet wet. However, it was Benjamin (2006) who took the real initiative and asked if he could come out and work with us. And everyone has benefited from his eagerness to do so. Noller's map (Fig. 21.2) now became the centrepiece in an on-going mental tug-of-war between optimism and scepticism over whether we should take the plunge or not. In the end, the decision was made to go for it. And we began to cobble together a team of divers for the underwater survey at Aspros in the summer of 2007. Again, there were friends and colleagues who thought that we were not making a wise decision. In their view, the risks of spending a good deal of time, money and effort and then coming up with nothing in the end were simply too great. However, we were now ready to take the chance. And we had the good fortune to focus our attention on the 'case-hardened' cliff at dive site C.

But the story is not over. In January and February of 2007, we took the next step and

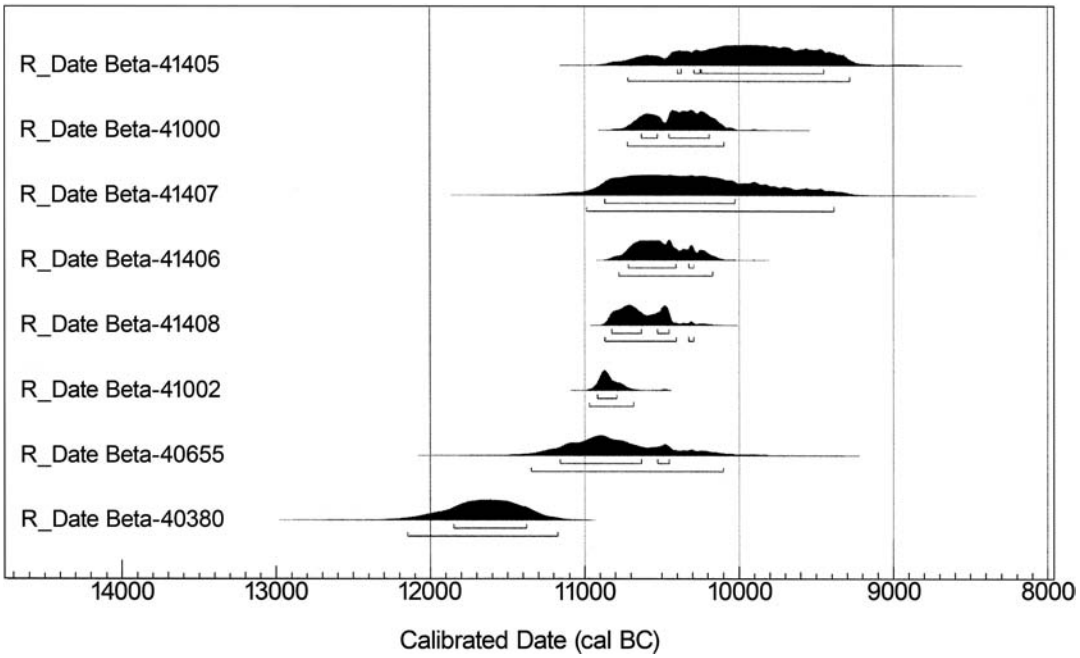

Figure 21.6: Two-sigma calibrated age ranges of eight radiocarbon dates run on samples of charcoal from stratum 2A at Aetokremnos. Calibrations performed with OxCal 4.0.1 (Bronk Ramsey 2001), using the IntCal04 calibration curve (Reimer et al. *2004)*

began to make trial excavations at Aspros and Nissi Beach. In low places on the aeolianite, there are patches of old soil that one can excavate. It was now possible to recover pieces of chipped stone in the context of a well-developed reddish-brown palaeosol at both sites. In the case of Aspros, the four small trial trenches excavated in 2007 all yielded a number of pieces of chipped stone. And the lithics – in terms of their raw materials, reduction technology, and tool types – were essentially the same as those found on the site's surface. However, in quantitative terms, the material recovered from a given trench was always quite modest (in the range of 7–25 pieces of chipped stone per square metre).

There was now the realization that such small numbers were probably to be expected since the places where we were digging were not located on or near the shoreline at the time but at a fair distance behind it. Thus, the results coming in from the excavations at Aspros now began to make their own separate case that the main places where the coastal foragers had once made their campsites were closer to the shoreline at the time. The two new areas that we excavated at Aspros in February of 2008 yielded much the same results. For example, the excavation in Area V, where the local outcrop of aeolianite made it a good place to sit, produced 16 pieces of chipped stone in a small, enclosed space, and half of them were tools. In short, this was a place on the landscape – once situated well back from the shoreline and visited only occasionally – where one or a few curated pieces of chipped stone were discarded from time to time. The real locus of human activity prior to 10,000 years ago must have been elsewhere. By this time in the project's evolution, we had already taken the plunge at Aspros and found the chipped stone pieces on the seabed at dive site C.

Finally, there was a new development at Nissi Beach that made us want to get our feet wet there for a different reason. It arose from the new observations on site formation processes that were made by Ioannis Panayides of the Cyprus Geological Service in 2008. He drew attention to the large number of beach rock fragments found on the site's surface and also in the top 4 cm of the soil (but not below this depth in the ground). Such pieces are now seen as the consequence of one or more tsunamis (Ammerman *et al.* 2008: 12–15, 29). In other words, there is an inverted stratigraphic sequence at Nissi Beach. The oldest lithics are found on top where they occur in a redeposited context. This material rests in turn on a well-developed palaeosol, which has yielded *in situ* features and chipped stone tools (made in a related but somewhat different lithic tradition) that date to the 8th and 7th millennia cal BC on the basis of AMS dates run at Oxford. The radiocarbon dates are coeval with those produced by a site of Pre-Pottery Neolithic age on Cyprus such as Shillourokambos.

The new evidence at Nissi Beach came as a

complete surprise to us. No one had expected to encounter the persistence of coastal foraging down to such a late date (e.g. Ammerman 2011). This now means that there was once the coexistence of first farmers and late coastal foragers on the island. Nissi Beach is accordingly adding a whole new chapter to 'Neolithic' studies on Cyprus. The excavation of a larger area at the site in February of 2009 confirmed the inverted stratigraphy at Nissi Beach. This gave us a further reason to learn more about the nature of things on the seabed in front of the site.

It is worth adding briefly here that an underwater feasibility study was initiated at Nissi Beach in June of 2009. The work was exploratory in nature, and it was done over the course of four days. One of its main aims was to learn more about the submerged relief and geology in front of the site. This is not the time or place to go into a detailed account of what was observed in the water. A finding of special interest was the identification of a low ridge of aeolianite at a depth of 36 m that runs parallel to the coast and steps down on its seaward side. In short, the ridge – much like the one occurring at the site of Nissi Beach itself – offers a flat area some 100 m wide, which would have made a good place for a campsite near the coast at the time of the Younger Dryas. It was concluded that the submerged landscape off Nissi Beach appears to have potential for underwater prehistory.

Conclusion

In closing, it is worth adding a few words about where the underwater study of coastal foragers on Cyprus stands at the present time as well as what needs to be done next. The main point to make here is that the first steps have only been taken in the last few years, and these steps have to be seen as modest and exploratory ones.

Prior to 2006, no proper study of this kind was undertaken on the island. In fact, even as late as 2003, there was only one good candidate for a pre-Neolithic site on Cyprus. The situation has now changed. Of course, a great deal remains to be done at Aspros and Nissi Beach and elsewhere around the island. In the case of dive site C at Aspros, it would make good sense to bring in equipment that will make it possible to process a large volume of sediment and obtain a larger sample of stone tools. At the same time, there is the need to conduct more detailed studies on the nature of the sediments themselves.

So we are, on one hand, just at the beginning of this kind of work on Cyprus. On the other hand, if one looks back and takes the long view, the work at Aspros represents a turning point (Ammerman *et al.* 2008: 27). Although it was well known that sea levels around the world were lower in the time before 6000 years ago and this was a concept that had entered the archaeological literature on Cyprus some years ago (Gomez and Pease 1992), there was for many years no attempt by the prehistorian to rise to the challenge and search for early sites in the water. The idea that what one finds on land is the tip of the iceberg was just that: simply a working hypothesis (something that could be either right or wrong). Now this uncertainty has been removed. What is found on land at Aspros is indeed just part of the picture. The world of early coastal foragers on Cyprus has to be seen as larger and richer than the prehistorian had previously envisioned.

In retrospect, this is something that should come as no surprise. If we consider what has come to light in the Baltic Sea and the North Sea over the last thirty years (cf. multiple authors in this volume), this is what we should have expected all along. The real surprise then is the time lag between the developments in Northwest Europe and those in the Eastern Mediterranean. The notable exception here is the excellent work that has been done at the submerged Neolithic settlement of Atlit-Yam off the Carmel coast of Israel (e.g. Galili *et al.* 2004; Galili and Rosen, this volume). What is implied here is that those who work on submerged early sites in the Eastern Mediterranean still have much to learn from their colleagues in Denmark, Germany, and Great Britain.

The challenge then is the transfer of technology and experience from one region of Europe to another one. It will take time, international collaboration, and proper funding to accomplish this. So far, all of our work in the water on Cyprus has been done on a shoestring. In other words, the investigations in front of Aspros and Nissi Beach are pioneering efforts that drew upon the goodwill of those on our dive teams. In moving to the next stage of the investigation, what is called for is a joint international project that will enable us to work on a larger scale and with the latest equipment. In addition, given the age of the earliest coastal foragers on the island (older than 10,000 cal BC) and the low position of sea levels at the end of the Last Glaciation, we shall probably have to think in terms of diving

to greater depths in the water. Otherwise, much of the submerged picture will remain missing. In turn, this will call for a more technical approach to diving.

At the *Submerged Prehistory* session of the European Association of Archaeologists (EAA) meeting 2009, it came as something of an eye-opener to learn that comparatively little work on early sites in European waters has been done at depths of more than about 15 m so far. In the recent exploratory work in front of Nissi Beach, we observed submerged areas at depths of more than 30 m where the aeolianite may well offer a good place for early campsites. Thus, Cyprus, notwithstanding its late start, may one day have a significant contribution to make to the field of submerged prehistory in Europe – perhaps comparable to the role that the island now plays in the study of the origins of seafaring in the Mediterranean world.

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Submerged Neolithic Settlements off the Carmel Coast, Israel: cultural and environmental insights

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Inundated Neolithic settlements, dated to 7200 to 6000 cal BC, were exposed off the Carmel coast of Israel as a result of erosion. The late Pre-Pottery Neolithic (PPNC) village of Atlit-Yam revealed human burials, rectangular stone structures, megalithic structures, and stone-built water wells. Subsistence was based on a combination of agro-pastoral activity and marine resource exploitation. Hunting continued together with herding of domesticated sheep and goats and incipient herding of cattle on the verge of domestication. The development of wells that utilized coastal aquifers enabled permanent human habitation near the coastline for the first time in this area. The later Pottery Neolithic (PN Wadi Rabah Culture) sites revealed olive oil extraction installations and water wells constructed of wood and stones. At the Neve-Yam PN site, human skeletons were discovered in stone graves. The PN sites demonstrate a fully agricultural subsistence economy. The submerged Carmel coast sites demonstrate the emergence of the Mediterranean fishing village on the south Levant coast. The emergence of the separate burial ground at Neve-Yam and the question of the separation of the living from the dead is discussed and explained. The beginning of olive oil extraction, a major component of the Mediterranean subsistence, is demonstrated at Kfar Samir. The earliest known case of tuberculosis is reported from Atlit-Yam.

Keywords: underwater archaeology, PPNC, Wadi Rabah, burials, water wells, olive oil, Mediterranean diet, fishing village, sea-level rise

Introduction

Postglacial sea-level rise inundated prehistoric settlements situated near ancient coastlines. Remnants of such settlements, dated to the Neolithic period *c.* 7200–6000 cal BC, have been found underwater off the Israeli Carmel coast (Fig. 22.1). They belong to two chronological entities: the Late Pre-Pottery Neolithic (PPNC) *c.* 7200–6300 cal BC, and the Late Pottery Neolithic (PN, Wadi Rabah Culture) *c.* 6000–4700 cal BC, and they were uncovered as a result of intensive sand quarrying and construction of marine structures. Underwater archaeological surveys and excavations have enabled a reconstruction of the material culture and the socio-economic system of the Neolithic inhabitants of the Levantine coastal plain. Additionally, they made it possible to reconstruct the palaeoenvironment and study its impact on coastal habitations during this important period in the development of Neolithic lifeways in the Old World.

The Atlit-Yam PPNC submerged village thrived from *c.* 7200 to 6500 cal BC. It is located in the north bay of Atlit, submerged at a depth of 8–12 m, and extends over approximately 40,000 m^2 (Fig. 22.2). Excavations revealed foundations of rectangular stone structures, round installations, a monumental structure built of sandstone megaliths (Fig. 22.2, structure 56; Fig. 22.3), anthropomorphic stone stelae,

stone-built water wells (Figs 22.4–6), and some 35 hearths with associated charcoal remains. The tools found were made of stone, bone, and flint, and include axes, spearheads, sickle blades, and arrowheads. Sixty-five human skeletons buried in flexed (foetal) positions were also uncovered (Fig. 22.7) in and around the structures. Organic remains include animal and fish bones, numerous charred and waterlogged seeds, tree branches, and pollen. The organic remains suggest that the village's economy was complex, based on hunting, herding, fishing, and farming (Galili *et al.* 1993, 2004).

Numerous Pottery Neolithic remains were revealed in a narrow, almost continuous distribution zone: a submerged belt *c.* 15 km long and 200 m wide, which runs parallel to the modern shoreline of the north Carmel coast. It includes five PN sites dated approximately to the 6th millennium cal BC, all situated at water depths of 1–5 m (Fig. 22.1) (Wreschner 1977a, 1977b, 1983; Galili and Weinstein-Evron 1985; Galili *et al.* 1989, 1998; Horwitz *et al.* 2002, 2006). In these sites, stone- and wood-built structures were found, as were numerous stone, flint, bone, and pottery artefacts. Stone-built graves containing human skeletons were also discovered (at Neve-Yam), as were various types of installations and pits, some of which contained charred and waterlogged plant remains and animal bones. Excavations and surveys at Kfar Samir and Kfar Galim revealed paved floors, olive oil extraction installations (Galili and Weinstein-Evron 1985; Galili *et al.* 1997), and several wells constructed of alternating layers of branches and stones (Fig. 22.8; Galili and Weinstein-Evron 1985). Additionally, round pits containing plant remains (mainly broken olive stones and pulp)

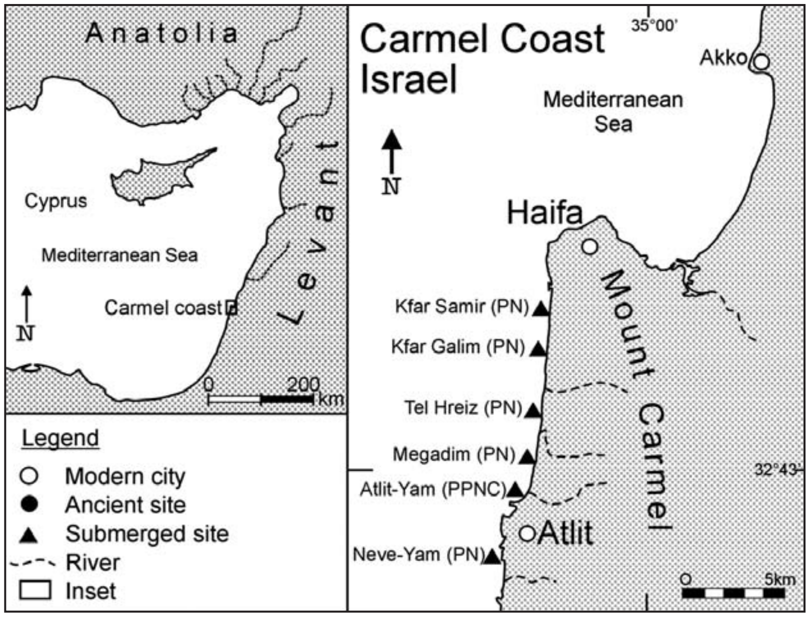


Figure 22.1: The Carmel coast and submerged prehistoric sites referred to in the text

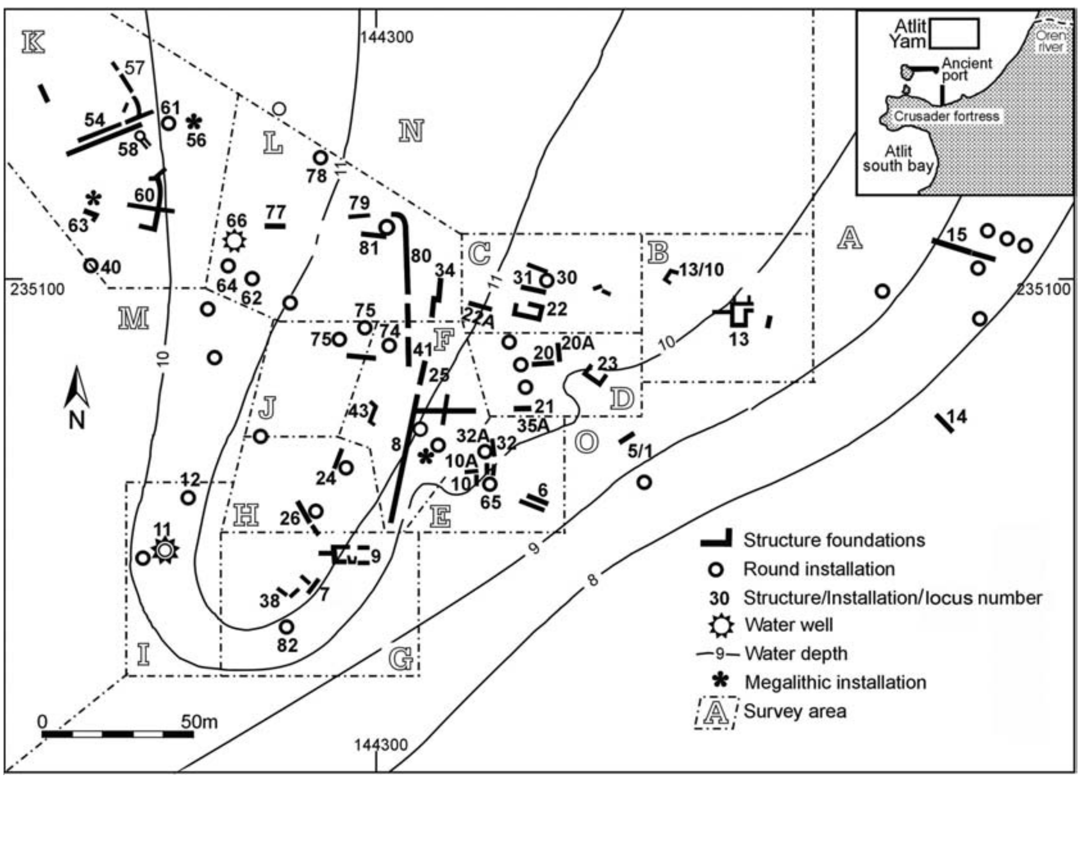


Figure 22.2: Plan of the Atlit-Yam PPNC site and location of installations mentioned in the text

Figure 22.3: The megalithic structure at Atlit-Yam: Top: measuring the structure. Bottom: excavating the adjacent seabed (Photos: Itamar Greenberg)

Figure 22.4: Atlit-Yam water well no. 11 during excavation (Photo: Itamar Greenberg)

were found together with wooden bowls (Fig. 22.9), fragments of woven reed mats, and stone basins (Fig. 22.10).

The water wells of Atlit-Yam

At Atlit-Yam, about 30 round stone features, each with a diameter between 0.8 m and 1.5 m, were identified, and two were excavated (Fig. 22.2: structures 11 and 66). Structure no. 11 (a well) was excavated down to its bottom, 5.5 m below the present seafloor and 15.5 m below the present sea level. The other well (no. 66) was partly excavated to a depth of about 1 m. Other (unexcavated) round structures in the site probably also served as water wells and storage pits (Galili and Nir 1993; Galili 2004).

Well no. 11 was cylindrical, 5.5 m deep and 1.5 m in diameter (Figs 22.4 and 22.5). Its upper section was built in undressed stone. Three courses had survived *in situ* above the present seafloor forming a wall (0.7 m high) that circled the open shaft and prevented the introduction of foreign objects. The uppermost 3.6 m of the well were dug into clay sediments and surrounded by 22–25 courses of stones. The number of stones in each course varied between 14 and 24. The lower section, 3.60–5.15 m below the site surface, was excavated into carbonate-cemented quartz sandstone ('kukar').

The fill of well no. 11 was excavated by a dredging system and underwent a series of wet and dry sieving (Galili and Nir 1993; Galili 2004). It presents a complex multi-layered deposit, which can be divided into three main sedimentation phases. The upper phase was composed of small and medium (3–15 cm) undressed kurkar stones and broken limestone pebbles, most showing signs of exposure to significant heat. This phase also contained carbonate sand composed of crushed shells and whole mollusc valves (*Glycimeris* sp.) – all probably late intrusions.

The middle phase extended from just below the previous land surface down 2.10 m. It contained animal bones (few in partial articulation), waterlogged and charred plant remains, and hundreds of flint, stone and bone artefacts, and waste from flint working. The fill was composed mainly of soft clay, small and medium sized stones, with some quartz and carbonate sand present. Lenses of very fine, soft

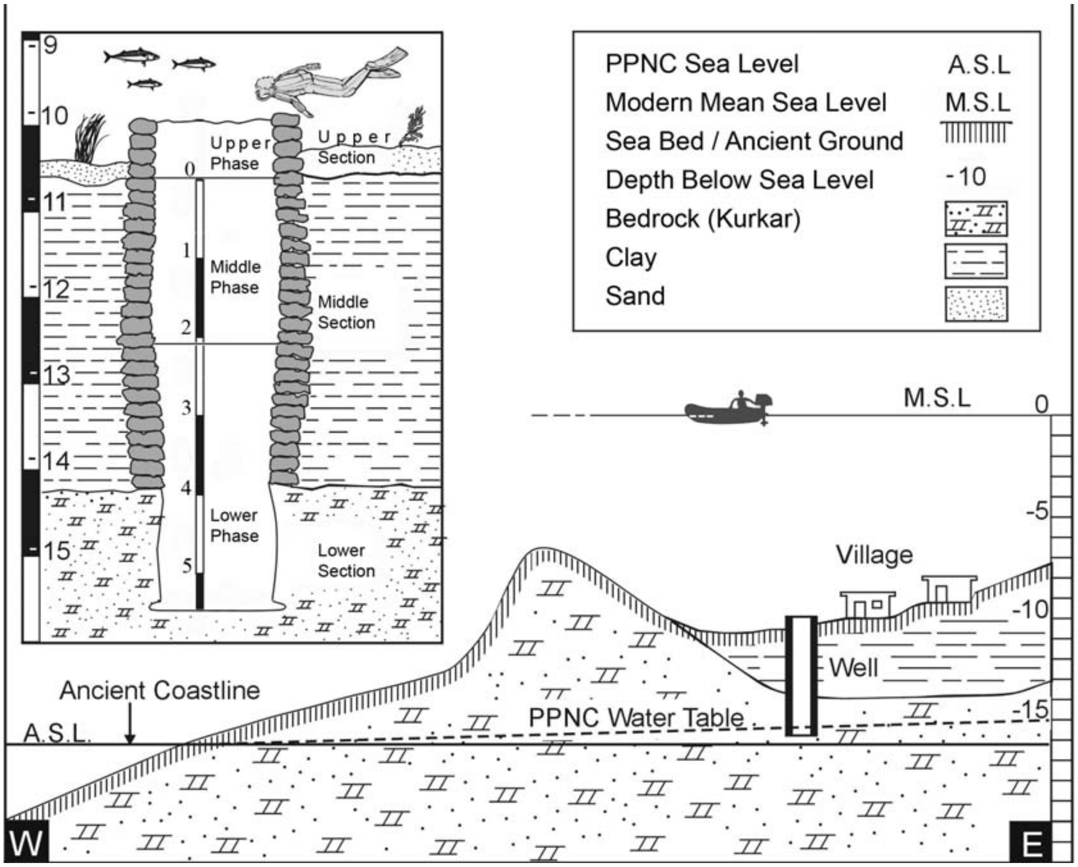


Figure 22.5: Cross-section of Atlit-Yam well no. 11 and schematic reconstruction of the topography and sea level at the site during PPNC

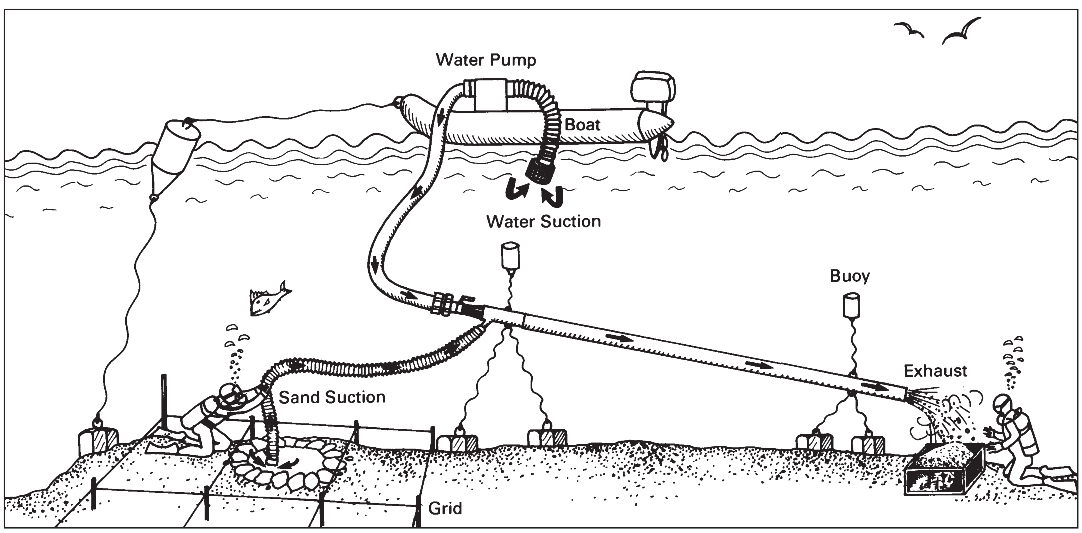


Figure 22.6: Excavation methods of the Atlit-Yam wells

Figure 22.7: Skeleton of a young woman buried in a flexed position at the Atlit-Yam site (Photo: Ahuva Zaid)

Table 22.1: Radiocarbon dates from the submerged settlements off the Carmel coast: RT = Weitzman Institute, Israel (Carmi and Segal 1996; E. Boaretto, pers. comm.); PITT = Pittsburgh, USA; PTA = Pretoria, South Africa, Beta = Beta Analytic Inc., Miami, Florida, HV = Hanover Radiation Laboratories USA. Calibrations performed using OxCal v4.1.7 (Bronk Ramsey 2009) and the IntCal09 dataset (Reimer et al. *2009)*

Material dated and context	Lab. ref.	Uncalibrated ^{14}C age BP	Calibrated age BC (2σ)
Atlit-Yam			
Charcoal, structure 13	PTA-3950	8000±90	7165–6649
Charcoal, structure 13	RT-707	8140±90	7453–6826
Charcoal, structure 10A	RT-944A	7670±85	6680–6390
Charcoal, structure 10A	RT-944C	7610±90	6641–6256
Charcoal, structure 10A	PITT 0622	7550±80	6568–6237
Wood, well 11	RT-1431	7300±120	6425–5984
Wood, well 11	RT-2479	7460±55	6431–6232
Wood, well 11	RT-2477, 2478	7605±55	6591–6387
Wood, well 11	RT-2475	7465±50	6427–6238
Wood, well 66	RT-2495, 2493	7755±55	6679–6471
Wood, well 66	RT-2489	7880±55	7029–6606
Charcoal, structure 32	RT-2681	6580±35	5615–5478
Charcoal, structure 54	RT-3038	8000±45	7061–6709
Charcoal, structure 56	RT-3043	7250±45	6220–6030
Charcoal, structure 65	RT-2497, 2496	8170±55	7333–7058
Neve Yam			
Charcoal, centre of site – dwellings	HV-4256	6310±395	6003–4373
Charcoal, south side – cemetery	RT-1723	6390±70	5481–5223
Charcoal, south side – cemetery	RT-1724	6565±70	5630–5376
Kfar Samir			
Wood, well 113	Beta-82851	5860±140	5198–4373
Wood, well 5	RT-682B	6470±130	5664–5081
Wood, well 3	RT-682A	6670±160	5898–5318
Wood, well 5	PTA-3820	6830±80	5895–5570
Wood, well 3	PTA-3821	6830±160	6015–5482
Wood, pit 10	Beta-82850	6940±60	5981–5718
Olive pit, installation 6	Beta-82845	6080±70	5213–4810
Olive pit, installation 6	Beta-82846	6210±150	5476–4801
Olive pit, installation 6	Beta-82847	6210±80	5341–4947
Olive pit, installation 6	Beta-82848	6230±80	5370–4965
Olive pit, installation 6	Beta-82715	6500±70	5611–5324
Olive pit, installation 6	RT-1898	5790±55	4781–4505
Olive pit, installation 6	RT-1930	5870±70	4929–4548
Olive pit, installation 7	Beta-82843	6100±60	5213–4849
Olive pit, installation 7	Beta-82844	6290±60	5465–5064
Olive pit, installation 7	RT-1929A	5630±55	4584–4350
Olive pit, installation 7	RT-1929	5870±70	4929–4548
Wood, installation 9	Beta-82849	6350±90	5484–5071
Mat fragment, installation 8	RT-855	6420±120	5620–5078
Wooden bowl	RT-1360	7230±80	6327–5923
Tel Hreiz			
Wooden fence	RT-779A	7330±120	6430–6003
Wooden fence	PTA-3460	6310±70	5470–5076
Wooden fence	RT-779B	6260±150	5508–4842
Wooden fence	RT-2480	6150±30	5211–5008
Megadim			
Clay	PTA-3652	7960±70	7056–6661

Material dated and context	Lab. ref.	Uncalibrated ^{14}C age BP	Calibrated age BC (2σ)
Bone	PTA-3648A	6310±70	5470–5076
Bone	PTA-4339A	6270±50	5358–5069
Kfar Galim			
Wooden structure – well	RT-1748	5985±70	5052–4713
Wooden structure – well	RT-1749	5985±55	5001–4726
North Kfar Galim			
Branch	RT-1750	6890±50	5887–5673

clay were attached to the walls. There were two clear layers of medium to large (15–30 cm long) stones embedded at 90–110 cm and 180–200 cm respectively below the former land surface. Traces of gypsum, found *c.* 80 cm below site surface, testified to high-salinity conditions. Around 180–210 cm below site surface numerous land snails were found.

The lower phase, 200–500 cm below surface, contained kurkar stones of various sizes embedded in sandy clay, various flint, bone, and stone artefacts, and a few animal bones and sediments typical of coastal water wells (Nir and Eldar-Nir 1986, 1987, 1988; Galili and Nir 1993). Three ^{14}C dates on wood (Table 22.1: RT-2475, RT-2477/78 and RT-2479) from this lowest section, have a 2σ calibrated age range of 6450–6250 cal BC after averaging (cf. Galili 2004; E. Boaretto, pers. comm. 2005).

Relative to the central phase, the lower phase of the well contained more plant materials. In striking contrast to the lower section of the well, there were hundreds of animal bones in the central section, undoubtedly representing discarded consumption debris deposited in a well that was no longer in use. Materials in those layers were typical of refuse associated with human habitation. Stone tools recovered from the upper section of the well were mostly broken and some of the stone bowl fragments show signs of mending (by piercing and sawing) or reuse (by flaking and turning them to scrapers). In the lower section, ornaments and decorated artefacts were found and only a few broken tools were present.

The presence of few articulated bones in well no. 11 indicates a deposition where the bones were still combined with soft tissue. It is unlikely that people would pollute their primary freshwater source with such waste. It is however likely that the well ceased to be productive because of seawater seepage due to continuous sea-level rise (Galili *et al.* 1993; Galili and Nir 1993). The presence of gypsum, indicative of high salinity, supports this proposition. The layers of large stones may be seen as attempts at heightening the bottom of the well for the purpose of obtaining water from higher aquifer levels.

Well no. 66 was dug into layers of clay. One course of undressed stones survived above the surface. The circular feature was 110 cm in diameter and the fill contained soft clay with hundreds of small and medium size stones. Faunal remains included *c.* 400 bones of herbivores, carnivores, rodents, reptiles, and fish. Few human bones were found. Artefacts made of flint, stone and bone were also recovered, and it is noteworthy that most of them were broken.

Re-use of excavated shafts and abandoned wells as garbage pits can be seen in other prehistoric sites, including Mylouthkia on Cyprus (Peltenburg *et al.* 2001), Sha´ar Hagolan in Israel (Garfinkel *et al.* 2005), and in Europe (e.g. Weiner 1998).

The PN water wells

PN water wells constructed of wood and limestone were found at the Kfar Samir and Kfar Galim sites. In Kfar Samir one such well was excavated to a depth of 2 m below the seabed (Fig. 22.8), at which depth its bottom was not

Figure 22.8: The well at Kfar Samir (Photo: Ehud Galili)

Figure 22.9: Wooden bowl uncovered at the Kfar Samir site (Photo: Josef Galili)

reached. The well had a 100 × 80 cm rectangular opening, and was built of alternating courses of branches and limestone. In its lower parts, two courses of stone were laid between the horizontal wooden construction elements. The fill consisted of soft clay with small pieces of stone, bird bones, olive stones, ceramic fragments, and flint flakes. It also included straw fragments, which were probably the remains of a mat.

Dating the water wells

Atlit-Yam was dated by ^{14}C analysis of charcoal from hearths and wooden remains from the fill of wells (Table 22.1). The dates of the wells' fills are slightly later than the dates of the hearths' charcoal. The wells were probably dug and constructed during the early stage of the village. The relatively late dates from the well are probably due to cleaning activities, which removed earlier deposits. The dates of the PN Kfar Galim and Kfar Samir wells are more representative as they were obtained from materials used in laying the walls of the wells.

Sustainable freshwater supply: a pre-condition for permanent coastal settlement

Freshwater availability is essential for humans and their livestock. In early prehistory only limited quantities of drinking water could be transported long distances. Nonetheless, a dramatic increase in human need for water took place with domestication and the introduction of husbandry. In the arid and semi-arid Israeli coastal plain, the availability of drinking water is a continuous problem in sedentarization. Shortage of perennial water sources made extensive areas uninhabitable. Throughout

Figure 22.10: Diver examining a stone basin that may have been used for crushing olives at the Kfar Samir site (Photo: Ehud Galili)

history, humans developed methods of procuring and storing water by constructing reservoirs, cisterns, canals, and wells. Water wells, unlike cisterns, generally provide high discharge and a permanent water source.

There is a paucity of information concerning well evolution in the Levant, and among the few known are: the PN unlined wells at Lemba, Cyprus (Peltenburg *et al*. 2001), the Sha'ar Hagolan stone-walled Yarmukian well (Garfinkel *et al*. 2005), the Late Neolithic well at Hacılar (layer VI, *c*. 5500–5400 cal BC) in southwestern Anatolia (Mellaart 1961), the Chalcolithic wells at Abu Hof (*c*. 4000–3200 cal BC) in the Israeli Negev (Alon 1988), and in Rajajil (*c*. 4000–3200 cal BC), north Arabia (Zarins 1979). By the Middle Bronze Age (*c*. 2200 cal BC) wells had become widespread and usually consisted of a round structure built of cut stones (Nir and Eldar-Nir 1986, 1987, 1988).

In an area rich in economic resources, but lacking fresh water, establishing wells is rewarding. Wells allow for the development and occupation of new territories. Wells increase carrying capacity of an area where water is a limiting factor. Thus, water well installation in the south Levant may be related to a terminal PPNB attempt to cope with shrinking environmental resources and to occupy new or previously underutilized areas. Parts of the Israeli coastal plain are situated above a high freshwater aquifer, which, given adequate technology, can be exploited year-round. Therefore, the early emergence of well digging in this region should not come as a surprise. Wells appeared much later in other areas of Western Asia such as the arid Saharo-Arabian and semi-arid Irano-Turanean inland Mediterranean climatic zones, or areas adjacent to rivers, deltas, or lakes.

It is likely that rapid changes in river courses and water availability in the southern Levant necessitated constant pursuits for freshwater sources (Tsuk 2000: 44). Such pursuits encouraged inhabitants to adapt and learn that water can be found underground. Thus, well-digging technology may have evolved in the PPNB when a need or decision to settle new territories arose. Creating a sustainable freshwater source on the coast enabled the establishment of permanent settlements, and this may then be closely associated with the emergence of Mediterranean fishing villages on coasts that lacked a visible surface freshwater supply.

Coastal wells and sea-level changes

The Pleistocene coastal aquifer of Israel drains westward toward the Mediterranean. A rise in

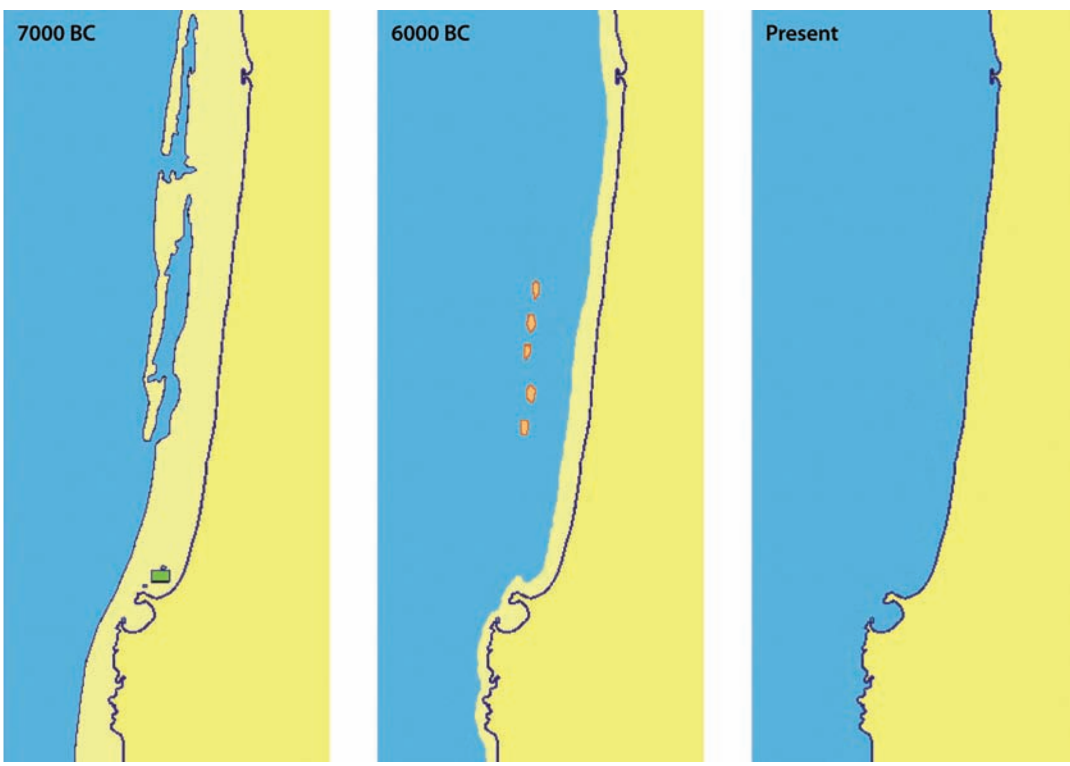
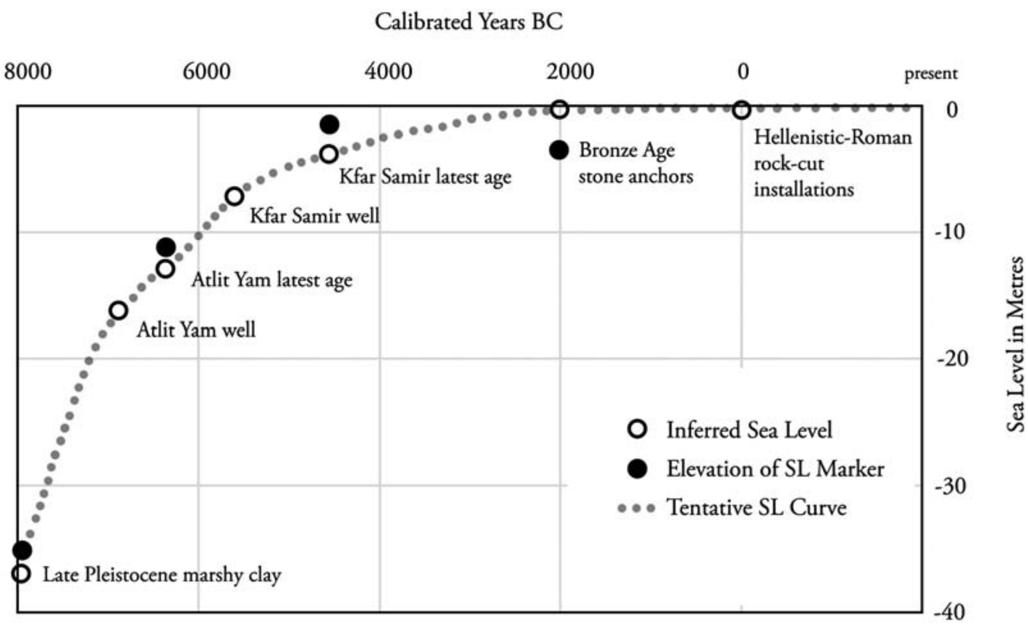


Figure 22.11: Reconstruction of Holocene coastlines on the Carmel coast at c. *7000 cal BC,* c. *6000 cal BC, and the present day*

Figure 22.12: Sea-level curve for the Carmel coast based on archaeological evidence



sea level results in a rise in the groundwater table and possible salination of wells. Observations on recent Israeli coastal water wells show that the groundwater table in these is very close to or slightly higher than the present sea level. The natural groundwater table slope in the Israeli coastal plain is in the order of 1:1000 (Kafri and Arad 1978). Thus, the groundwater table for a well that is situated 500 m inland from the shoreline would be 0.5 m above sea level. Studies of ancient wells along Israel's coastal plain showed that the average freshwater depth at the bottom of the wells was about 0.6 m (Nir and Eldar-Nir 1986, 1987, 1988). This column height is dictated by people's ability to dig beneath the water table, and by the fact that it was not necessary to have a deeper water column. An average water column of 0.6 m will generally supply an adequate amount of water.

The Atlit-Yam well bottom is about 15.5 m below modern sea level. This suggests that during the well's initial use, sea level was probably around 16 m (and certainly no more than 15 m) below present sea level (Fig. 22.5). Observations from other submerged wells indicate that during the PN, sea level in the Carmel area was *c.* 10 m lower than today (Galili *et al.* 1988, 2005). Combining these observations with bathymetrical and geological maps of the area makes it possible to present a reconstruction of the sea level and coastal changes along the northern Carmel coast, as shown in Figures 22.11 and 22.12.

It has been suggested that the Atlit-Yam village was destroyed by a catastrophic tsunami event generated by the collapse of a section of Mount Etna (Sicily) into the sea (Pareschi *et al.* 2006, 2007). However, based on current archaeological and geological evidence, it appears that the site was abandoned gradually due to global sea-level rise, rather than as a result of a tsunami (Galili *et al.* 2008).

The emergence of a Mediterranean fishing village

The Levantine and Cilician (southeast Turkish) seashore areas are the closest coastal environments to the inland regions where animals and plants were first domesticated. At the end of the 7th millennium and the beginning of the 6th millennium cal BC farming was practised on the Levantine coast, as evidenced by the material recovered from Atlit-Yam (and possibly also at the sites of Ashkelon Marina (Perrot and Gopher 1996) and Ras Shamra (Van Zeist and Bakker-Heeres 1984). This innovation, the agro-pastoral-marine subsistence system, the so called the Mediterranean fishing village, evolved among indigenous coastal inhabitants, who combined the imported agriculture and animal husbandry with hunting and foraging and intensive marine resource exploitation (Galili *et al.* 2002, 2004). The agro-pastoral components of this subsistence system relied on domesticated cereals and

legumes, sheep, goats, and cattle. Subsequently this coastally adapted subsistence system spread westward throughout the Mediterranean basin (Galili *et al.* 2002, 2004).

During the 5th millennium cal BC the extraction of olive oil was added to the economy of the Carmel coast area (Galili *et al.* 1997). The subsistence of the PN settlements was characterized by increased reliance on farming and animal husbandry, reduction of the exploitation of marine resources and hunting, and intensive use of secondary animal products (milk products, wool fibres, etc.). Later still, during the 4th millennium cal BC, other domesticated trees appeared. With the introduction of the domesticated grapevine and the production of wine in the Levant (Zohary and Hopf 2000) alongside the continuation of agro-pastoral food procurement and the exploitation of marine resources, the development of what is today commonly known as 'the Mediterranean diet' was completed around 3000 cal BC.

Early tuberculosis

Bones of a woman buried together with an infant at Atlit-Yam showed pathological deformations suggestive of tuberculosis (Hershkovitz and Galili 1990; Galili *et al*. 2005). Molecular examination of DNA from bones of both individuals yielded positive indications for this disease (Hershkovitz *et al*. 2008; Donoghue *et al*. 2009). It is believed that this is the earliest confirmed report of tuberculosis in humans (Roberts and Buikstra 2003). Previously, the earliest examples were from Predynastic Egypt, 3500–2650 BC (Zink *et al*. 2001), and Italy at the beginning of the 4th millennium cal BC (Formicola *et al.* 1987).

At Atlit-Yam cattle bones dominate the zooarchaeological record indicating their importance as a major dietary component. The absence of detectable *Mycobacterium bovis* (the bacterium that causes tuberculosis in cattle) in the cattle bones is interesting. It could be seen to support the theory for the spread of the disease as a result of a dense human population, rather than as a product of close contact with domestic cattle.

Separating the dead from the living

Salvage excavations and surveys in the submerged PN settlement of Neve-Yam (early to middle 6th millennium cal BC) revealed unique stone-built graves concentrated in a section of the site devoted to burials and related symbolic activities associated with death and mourning. It is significant to note that there were no signs of dwellings in the area of concentrated burials and, similarly, no graves in the dwelling area. The oval graves, oriented east to west, were built with undressed stones and covered by stone slabs. Previously, cist graves have been documented elsewhere in the Levant (cf. Banning 1995). This site is, however, one of the earliest known Neolithic settlements to exhibit a clear division between the living area and the cemetery. Three large concentrations of charred seeds in the cemetery zone suggest ceremonial activities, perhaps representing an early example of a ritual associating the dead with farming activities.

The evolution of extramural burial grounds in the southern Levant is demonstrated in several stages at the submerged PPNC and PN settlements off the Carmel coast. In PPNC Atlit-Yam burials were dispersed all over, but 45 of the 63 burials are concentrated in the site's northwest section (areas K and L). In PN Neve Yam**,** some 1200 years later than Atlit-Yam, burials were definitely concentrated in a separate section of the site devoted to burials and associated activities. During the Chalcolithic period, off-site and well-defined formalized cemeteries containing stone-built graves and ossuaries (made of stone or clay and imitating houses) are common in the southern Levant (Gilead 1988; Gal *et al.* 1995; Levy 1995; Gorzalaczany 2006).

This extramural mode of burial, which emerged, evolved and consolidated during the Neolithic period owing to the sedentary way of life associated with agriculture, has been practised by many human societies until today. It is proposed that the increasing penetration of the subsurface space by soil working and sedentary communities interfered with the dead and was a major factor in the evolution of the separated burial ground, the 'graveyard'. The new institution, 'the separated burial ground', was meant to resolve a three-dimensional territorial conflict between the dead and the living over the use of subsurface space.

Conclusions

Excavations of submerged settlements off the Carmel coast of Israel have demonstrated the development of a society moving toward an

Figure 22.13: Foundations of rectangular dwellings from the PN Neve-Yam site undergoing erosion (Photo: Josef Galili)

agricultural and sedentary lifestyle in the coastal area. Throughout this process, the diet of the inhabitants of the settlements was also dependent on marine resources. It appears that the sites were abandoned gradually as a response to sea-level rise, not as a consequence of dramatic flooding or tsunami. The discoveries at the inundated Atlit-Yam site demonstrate the existence of well-digging technology in this coastal region as early as the beginning of the 7th millennium cal BC, considerably earlier than in other Levantine territories inland. These are some of the many environmental and culture-historic conclusions that can be drawn from the rich *in situ* evidence of settlement, burials, wells, and faunal and floral remains found by archaeologists equipped with standard scuba diving equipment.

Even on the basis of this brief summary of evidence, it should be clear that the submerged Neolithic coastal settlements of the Carmel area hold crucial information for understanding the origins and diffusion of Neolithic lifeways in the Old World. For the future, underwater archaeology is likely to be the main source of new information on Neolithic coastal settlements.

The highest potential for finding submerged Neolithic settlements is in areas where special geological, environmental, and cultural factors have combined. Such sites are located near the coast, where natural factors or human actions cause erosion and exposure of palaeosols (Fig. 22.13). At times, the fringes of such sites can be traced on land. Thus surveys and excavation efforts should be concentrated in areas with these characteristics. An example of such conditions is found at water depths of 1–10 m off the Carmel coast, where the sediment cover is not too thick (enabling exposure) and not too thin (enabling preservation). In the Neve-Yam and Tel Hreiz sites, sections of the submerged settlements were first identified on land (Wreschner 1977a, 1977b, 1983; Ronen and Olami 1978; Olami 1984). However, most of the cultural deposits, structures and artefacts from the submerged prehistoric sites off the Carmel coast were discovered in the course of pre-planned, systematic surveys and excavations, undertaken since 1965 in the most promising areas.

We see no reason why other settlements of comparable age and preservation quality should not exist in shallow waters elsewhere along the Levantine coast. What may be found in deeper parts of the Levantine continental shelf can only be guessed at since these areas have not yet been

subject to systematic archaeological surveys and testing.

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23

Research Infrastructure for Systematic Study of the Prehistoric Archaeology of the European Submerged Continental Shelf

Nicholas C. Flemming

The slow but accelerating accumulation of data defining the sea-level changes, palaeoclimate, subaerial terrestrial soils, river drainage patterns, coastal marshes and peats, combined with properly controlled mapping and excavation of submerged archaeological strata in several locations, has encouraged the view that it is now possible to attempt a systematic analysis of the prehistory of the whole continental shelf, which can be integrated with prehistory on land. Such an endeavour will take many years to produce substantial results, and the foundations and preparations must be sufficiently robust to support a consistent accumulation of new data over this timescale. The present chapter reviews briefly the infrastructural conditions needed, and focuses on the exploitation of existing data already archived and the derivation of practical information for planning and interpretation of fieldwork.

Keywords: continental shelf, submerged prehistory, underwater archaeology, research infrastructure

Introduction

The logical inference that Pleistocene vegetation, terrestrial fauna, and humans existed on the area of continental shelf exposed subaerially during the Pleistocene glaciations was made by many authors before 1970. Dredged and trawled mammal bones, peat, and occasional human artefacts confirmed that the inference was probably correct. The key publications were those by Negris (1904), Boule (1906), Reid (1913), G. A. Blanc (1921, 1928), Garrod (1928), Doumergue (1934), A. C. Blanc (1937, 1940, 1942), North (1957), and Emery and Edwards (1966). They illustrate how well the authors appreciated the role of low sea level and the occupation of the continental shelf by a wide range of fauna including humans. Improved palaeoclimate models and chance finds continued to substantiate the proposition that the continental shelf had been occupied for much of the last million years, but few scholars attempted a systematic approach to analyze the extent and timing of such occupation, or its implications for European prehistory as a whole. The seabed data were sparse and random so that such an objective seemed futile.

During the last 15 years several authors have outlined the status and broad objectives of research into submerged prehistoric landscapes and archaeology offshore (Fischer 1995; Coles 1998; Bailey and Milner 2002; Flemming *et al*. 2003; Bailey 2004a, 2004b; Flemming 2004a, 2004b; Gaffney *et al*. 2007; Yanko-Hombach *et al*. 2007; Bailey and Flemming 2008; Faught and Flemming 2008; Peeters *et al*. 2009; Benjamin 2010). The situation is well stated in the Memorandum of Understanding for the European Union financed SPLASHCOS COST Action (http://w3.cost.esf.org/index.php?id=233&action_number=TD0902).

During 2010 English Heritage organized a new framework for offshore archaeology that will contain substantial sections on Palaeolithic, Mesolithic, and Neolithic submerged archaeology. Other assessments of Palaeolithic or Mesolithic research strategies, e.g. Pettitt *et al*. (2008), have assumed on intellectual criteria that the study of the prehistoric archaeology of Western and Southern Europe before 6000 years ago must logically include the study of the continental shelf.

During the same years the oldest identified occupation sites in Europe have increased from under 1 million years to 1.8 million, with 1.3 million in southern Spain (Scott and Gibert 2009), 1.8 million in Georgia at Dmanisi, and 0.8 million years in the UK (Parfitt *et al*. 2005, 2010). This has increased the timescale that needs to be considered and the complexity of data that need to be analyzed, especially for the earlier periods. The publication of the analysis of a Neanderthal skull fragment from the North Sea (Hublin *et al*. 2009) has drawn attention to the relevance of the longer timescales. It is interesting that Scott and Gibert (2009: 84) conclude their paper with the phrase 'The barrier between Africa and Europe was permeable'.

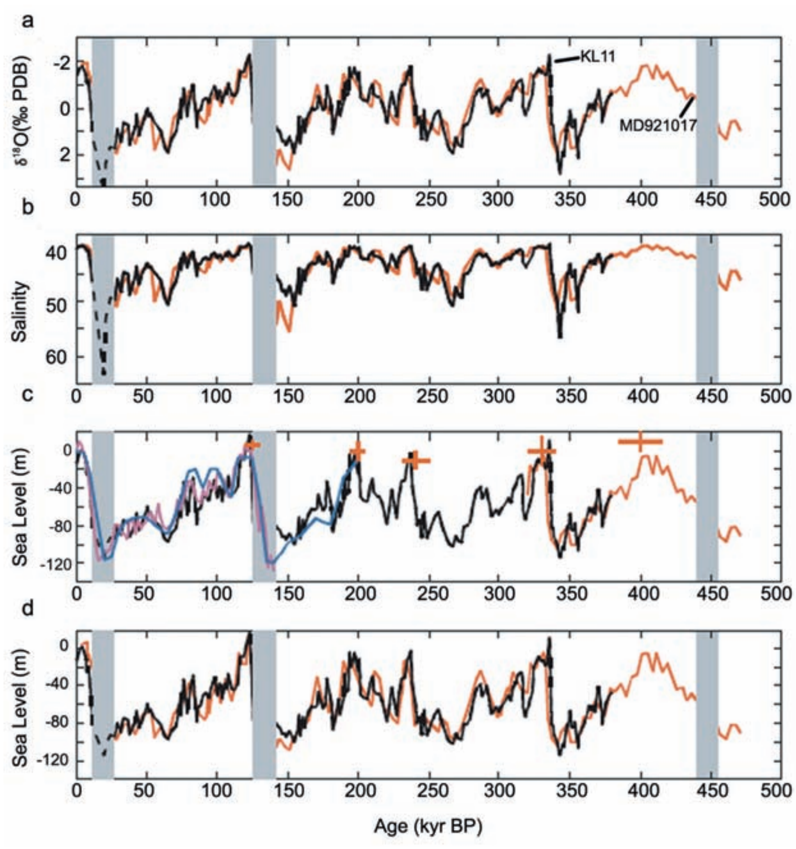


Figure 23.1: Curves for the [18]*O isotope anomaly, salinity, and sea-level for the Red Sea for the past 500,000 years. These values are derived from the analysis of sediment cores on the ocean floor, and are of wide value in assessing global sea-level change in response to high-latitude continental glaciations during the Pleistocene. Analysis conducted for oceanographic and climatological purposes is important for prehistoric archaeology (Rohling* et al. *1998)*

Objectives

It is not the purpose of this chapter to present an overview of other people's work, and many of the most recent developments are described by other chapters in this book. In this chapter I do not amplify or interpret the objectives identified by these authors other than to state that their work confirms the importance of the subject, and that their objectives in archaeological terms are worthwhile. The questions of feasibility and cost are another matter, and it is these, in part, that I address here. Many of the ideas expressed in this analysis have been developed during the workings of the Project Deukalion Planning Group and the submission of a successful proposal to the European Commission COST Action office, 'SPLASHCOS TD-0902'. I acknowledge that these ideas have been refined by frequent discussions with my colleagues in these groups, and thank them. Any errors and unjustified opinions are mine.

The progress of understanding and interpreting the integrated prehistoric archaeology of the European continental shelf requires the following consensus, agreements and infrastructure, either as scattered components that exist in a loose framework, or as specific and managed arrangements:

1. The intellectual case that this is an aspect of prehistoric archaeology that warrants investigation, and that the costs and allocation of effort, qualified staff, and money, is justified.
2. Sufficient trained archaeologists and scientists of other related disciplines such that the work on the continental shelf can be conducted with adequate skills.
3. Institutions and archaeological, earth science, and ocean technology agencies (see Fig. 23.1) with an interest in the offshore sector, and a willingness to work together at a European scale.
4. Access to funds, technology, sea-going vessels, and other resources needed to conduct the work on a steady basis over many years.
5. Access to large datasets and skills in the subject areas of climatology, glaciology, acoustic surveying, (see Fig. 23.2), seabed intervention, environmental reconstruction, modelling, palynology, sediment analysis, sedimentary processes, beach dynamics, etc.
6. Collaboration and exchange of new archaeological and palaeoenvironmental data on a regular basis, and the development of appropriate exchange media and archives.

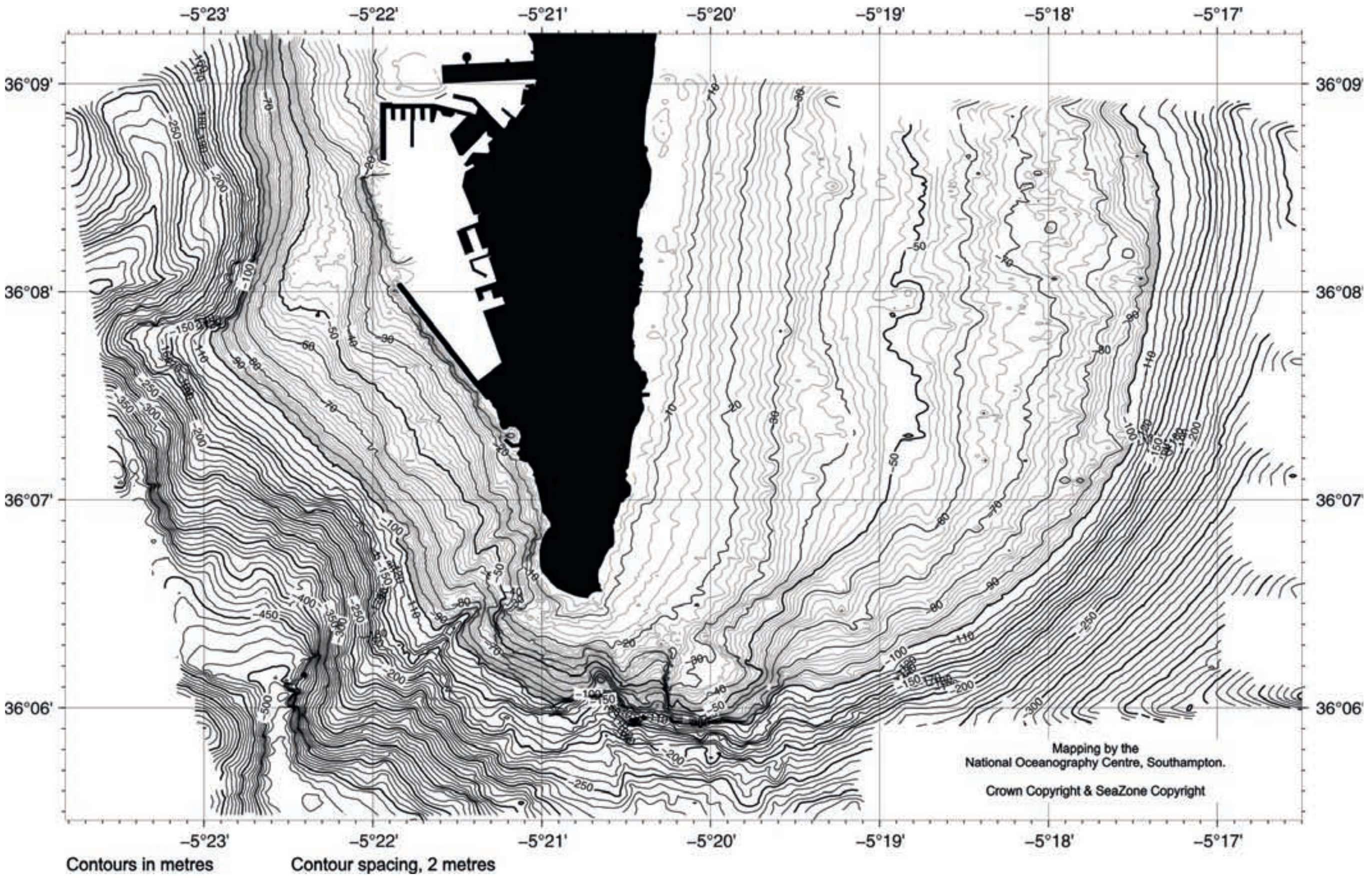


Figure 23.2: The bathymetric contours around the southern tip of Gibraltar, Europa Point, have been plotted with a contour interval of 2 m to reveal the submerged geomorphological features related to possible Neanderthal occupation of known submerged caves. This is based on digital single beam sonar records, with tracks separated by 50–100 m. The topography reveals a valley extending southwest from Europa Point, several rocky steep-sided outcrops, and a more gentle rolling plain to the east. There are submerged caves in the steep outcrops

7. Planning and implementation of fieldwork at all scales from the local, to regional and large-scale operations at a pan-European level, or requiring focused resources at a European scale of investment.
8. A strategic view of the progress of work, and an academic intellectual assessment of developments, with adjustments to plans or re-focusing of priorities. In effect, a long-term strategy that is periodically adapted.
9. Publication and dissemination of results at the highest refereed level, combined with public outreach and publicity.

These topics will be considered briefly in the next section.

Components of the European research infrastructure

1. The intellectual case

Individual prehistoric sites on the seabed, and regional assemblages of sites such as the southern Baltic, the central southern North Sea, and the Carmel coast of Israel have been studied since the early 1980s. However, the work has often been regarded as a fringe activity, tolerated rather than promoted by institutions and funding agencies. The important transition for European marine prehistory is the acceptance by a wide range of archaeologists, not just the keen divers among them, that European prehistory is seriously incomplete unless the exposed area of the continental shelf is taken into account at each phase of evolution over the last million years. This acceptance and recognition is typified by books such as Van Andel and Davies (2003), Stringer (2006), and strategic planning analyses and integration such as Pettitt *et al*. (2008), Harff and Lüth (2007), Peeters *et al*. (2009), and Westley and Bailey (in press).

The concern to understand the drowned Pleistocene landscape and its human occupation has been prompted also by work such as Broodbank (2000) on the central Aegean, and the growth in interest in island archaeology (Erlandson 2001). Other works addressing the case for studying the submerged prehistoric landscape have been cited in the opening section of this chapter. The realization that the output from such research is important has been tempered by the parallel realization that work

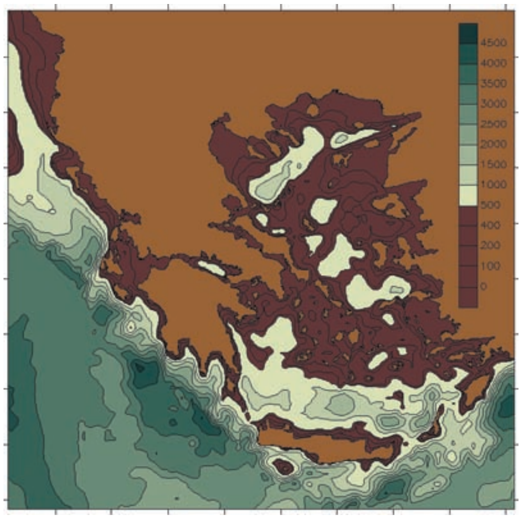


Figure 23.3: Migration across the Aegean–Black Sea region is a fundamental stage in the expansion of hominins from Africa into Europe. During Oxygen Isotope Stage 12 c. *480,000–350,000 years ago the Aegean was mostly dry with some scattered lakes, although Crete was not connected to the mainland. People could walk easily from the Middle East into Central and Western Europe. Seabed subsidence since that date caused by plate tectonics, combined with Pleistocene glacial low sea level, means that the original coastline was similar to the present 500 m isobath. The field research and analysis were done by the Hellenic Centre for Marine Research (Lykousis 2009)*

at sea and under the sea is slow, and potentially expensive. However, if professional archaeological skills are not applied to this problem, the unsupervised activities of well-intentioned amateurs and chance recoveries by industry will gradually remove the known deposits. The growth in general marine science capabilities in Europe, and the option to collaborate with oceanographic laboratories, provide a technical solution to this problem (see Fig. 23.3). It is now widely accepted that there is a justification on the grounds of advancing archaeological research and solving archaeological questions, which would otherwise remain impenetrable, to devote a substantial but cautious level of funding and resources to gathering data and analyzing and integrating the findings on the European continental shelf in a strategic manner.

There is the additional benefit that in many countries seabed prehistoric remains are protected by treaties and international agreements, as well as national regulations, and therefore the discovery and quantification of the remains is a prerequisite to their protection and management.

Tavke 23.1: Topics identified by respondents to Project Deukalion/SPLASHCOS correspondence

Climate change	Palynology	Recent tectonics
Sea-level change	Archaeology	Palaeolandscapes
Palaeoshorelines	Speleothems	Higher-resolution acoustics
Marine geology	Oceanography	Data management
Seabed excavation	Geochronology	Foraminifera
Heritage management	Submerged landscapes	Zooarchaeology
Survey technology	Sedimentology	Predictive models
Pleistocene geomorphology	Micropalaeontology	Marine robotics
Marine geophysics	Prehistoric migrations	Ancient seafaring
GIS mapping	Archaeobotany	Diving
Database management	Dendrochronology	Marine technology

2. The academic community, research personnel, and training

In preparation for the Deukalion Project to study the European prehistoric continental shelf the Planning Group developed an electronic contact mailing list of over 180 scholars and students in 27 countries (September 2009). There are a total of 98 personnel based in universities, 70 based in government agencies, 9 in small and medium enterprises (SMEs) or non-profit private bodies, and 5 unknown. The Project Deukalion address list contains detailed descriptions of the research interests of the respondents, which range over the topics listed in Table 23.1.

The study of the prehistory of the continental shelf is inherently multidisciplinary to a high degree, and most of the topics listed in Table 23.1 had several individuals mentioning that topic, so that the breadth and depth of interest of the community is apparent. Expressions of interest have been received from 27 countries, and of the respondents so far, 43 identify themselves as young researchers, i.e. people conducting research within ten years of completing their PhD.

The interested academic community is still sparse in some countries, and is generally weak in the areas of technology and seabed support operations. This can be countered by increasing the effort to involve oceanographic and fisheries laboratories, and industry. With these caveats, it is fair to say that the extent of scholarly interest across Europe is very encouraging.

Maritime archaeology is a composite subject that inevitably requires teams with several disciplines. Prehistoric marine archaeology is more complex than most branches of the subject, since the taphonomy of sites is so complex and varied (Fig. 23.4), and the area to be searched, described, understood, and possibly excavated can be very large or widespread. Training is required at every level, both to draw young people into the subject, and to provide more experienced archaeologists with an understanding of the required skills. Similarly, technologists, oceanographers, and engineers will have to understand more about the requirements of seabed prehistory research. The UNESCO Secretariat for the Convention on the Protection of the Underwater Cultural Heritage lists 37 training courses in marine and maritime archaeology in Europe spread through 12 countries. There are probably others not listed, and establishments providing training in most cases are also conducting research. It is uncertain how

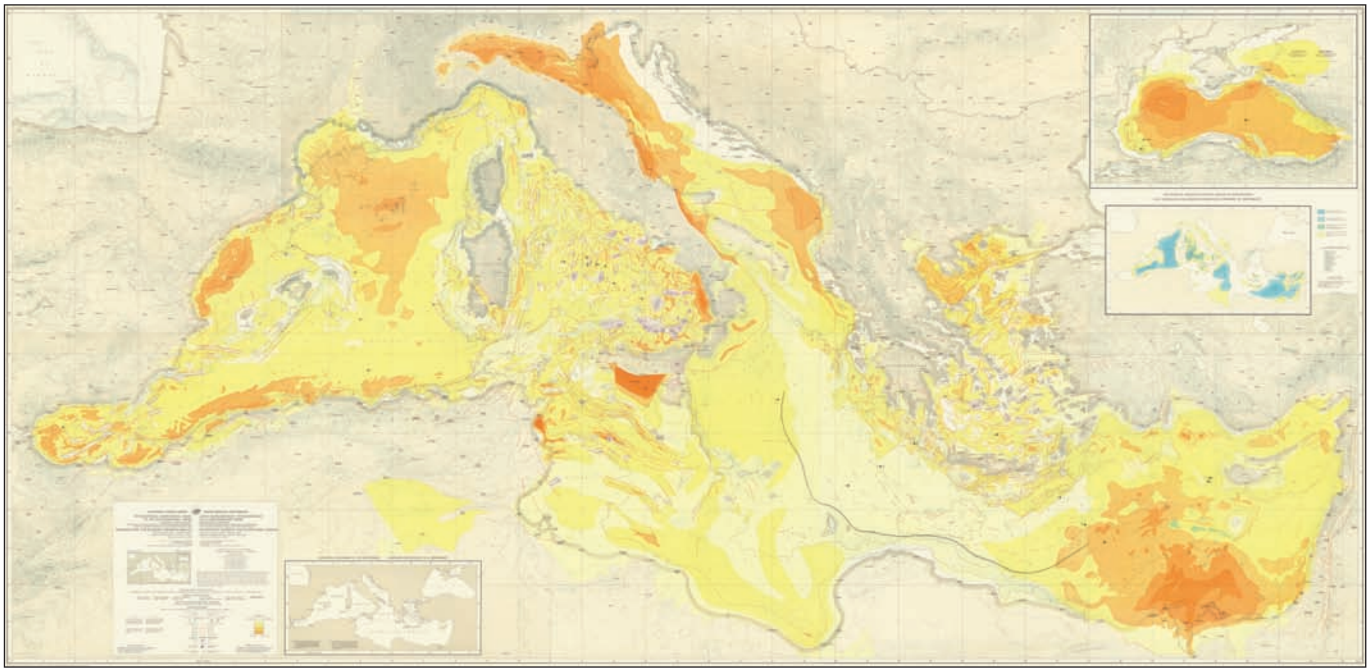


Figure 23.4: The thickness of unconsolidated sediments is a useful guide to the probable taphonomy of submerged prehistoric sites. Most of these sediments are either modern mobile marine sands and mud, or Pleistocene terrestrial deposits. In the Mediterranean this map shows the regional impact of the big rivers, Ebro, Rhone, Po and Nile, and the Danube in the Black Sea (© NOAA)

many courses provide components relating to prehistoric archaeology.

3. Types of institution

In the planning for Project Deukalion/SPLASHCOS, approximately 170 archaeologists and scientists responded with expressions of interest (April 2009) (see also Section 2 above) and their affiliation to various institutions gives a measure of the range of agencies and institutions that may be involved in future research in this field. Table 23.2 summarizes the data. It is noticeable that at this stage (2011) more participants are needed from the sectors of marine technology, acoustics, geophysics, robotics, submersibles, data management, and ship operations.

The European Commission Framework Programme stresses the importance of including SMEs as partners in EC-funded research projects. One objective in all research investment is to promote the transition from research funding supported by taxation to application by self-supporting organizations wherever possible. While this is not a major function in archaeological research, there are many aspects of site management, development archaeology, and technical support services that can be carried out in this way. Thus the SPLASHCOS study of the types of agencies and organizations involved in marine prehistoric archaeology is particularly concerned with establishing whether SMEs are involved or not. If they are not at present responding to SPLASHCOS enquiries, and if we know that SMEs do exist in a given sector, then we should make an effort to contact those organizations. For this reason Table 23.2 shows null values against some categories. This requires action.

The analysis is based on the address table of Project Deukalion/SPLASHCOS in April 2009. The proportions and ranking of the figures are stable, and the addition of further institutions is unlikely to alter the ranking significantly unless a special effort is made.

The ranking is heavily dominated by the categories of university departments of archaeology and earth sciences, with a combined total of 78, making 46% of the total, or 82% of all university responses. This interest is to be expected, but, given the objectives of SPLASHCOS/Deukalion, the low scores on university engineering, oceanography, and technology need to be corrected. Every effort should be made to draw in research agencies and university departments working in the area of offshore oil and gas, robotics, and surveying.

Government agencies show the same bias, with 38 respondents in archaeology and earth science, out of a total of 60, i.e. 63% of government agencies. Again, in the government sector, engineering and marine technology is low. It is interesting that there are more government agencies dedicated to marine archaeology than

No.	Agency	No. of Respondents	Rank
1	University Department of Archaeology; University Museum	45	1
2	University Department of Oceanography	5	8=
3	University Department of Earth Sciences	33	2
4	University Department of Engineering, Technology, Ship Science, Research Vessels	7	6=
5	Other University Department (e.g. dating techniques, genetics, DNA)	1	14=
6	University Department Marine Archaeology	4	10
7	Government Agency: Archaeology, Heritage, Museum	26	3
8	Government Agency: Oceanography	3	11=
9	Government Agency: Earth Sciences	12	5
10	Government Agency: Engineering, Technology, Ships	3	11=
11	Government Agency: other	0	
12	Government Agency: Marine Archaeology	16	4
13	Commercial/SME: Archaeological Heritage	1	14=
14	Commercial/SME: Oceanography	0 (see text)	
15	Commercial/SME: Earth Sciences, Climate	0 (see text)	
16	Commercial/SME: Engineering, Technology, Ships	1	14=
17	Commercial/SME: Other (e.g. data management, data processing)	2 (see notes)	13
18	Commercial/SME: Marine Archaeology	7	6=
19	Unknown	5	8=
	Total (N)	**169**	

Table 23.2: Agencies, university departments, and SMEs expressing interest in continental shelf prehistory through correspondence with Project Deukalion/SPLASHCOS (N=169)

there are university departments (16 *versus* 4). In the SME category there are seven companies/bodies dedicated directly to marine archaeology, which is very healthy, but the small number of SMEs in other categories requires action.

4. Access to funds and technology

The case for conducting systematic research in European submerged prehistory depends first and foremost on the judgement of experienced archaeologists that the research results will be important (e.g. Bailey and Flemming 2008), and secondly on the need to assess and manage the cultural heritage resources as required by national and international law. The range of environments and the range of depth from the shoreline to 150 m determines the costs of survey and excavation activities, which may be nearly as cheap as those on land for shallow sheltered waters, or cost many thousands of euros per day for operations requiring a well-equipped research vessel with seabed intervention technology.

Seabed prehistoric remains are included in the UNESCO Convention on the Protection of the Underwater Heritage, and by the Valetta Convention. National governments and cultural heritage agencies are progressively revising their priorities and terms of reference so as to make the prehistoric continental shelf an identified topic of concern, not just an incidental afterthought. This can require time-consuming revision of legislation so that agency responsibilities can be redefined to apply beyond territorial seas.

Given governmental recognition and agency responsibility for seabed prehistoric research and protection of the cultural heritage, some research funds are forthcoming, either directly or through universities. The number of university departments identified and summarized in Section 3 testifies to the level of interest, although budgets are certainly very limited in most cases. As national regulations require offshore commercial operating companies to conduct pre-disturbance research for prehistoric remains on the seafloor, and to monitor their operations, commercial archaeological consulting companies are conducting useful work as subcontractors. This brings more money into the field, and it is essential that the results of such work are made available through openly published reports and in academic journals or through collaboration with universities.

Although a few research vessels are operated and funded purely for marine archaeology, it is in general more economic and effective both in cost and logistics for archaeologists to charter

vessels for short periods to support projects, or to work in collaboration with laboratories operating research ships. The oceanographic and earth sciences laboratories own and operate a range of vessels from coastal to global range, which are equipped with a range of acoustic and mechanical technology that is routine for them but relatively unusual for archaeologists. Joint or collaborative projects thus become an efficient way of gathering the palaeoenvironmental data that are an essential part of prehistoric archaeology.

The largest scale of potential funding for continental shelf prehistoric archaeology and landscapes is through the European Commission. The COST Action TD0902 provides the community with four years of pump-priming funds to strengthen the community itself and improve training and technology transfer, but it will not fund new research. For the right level of research funding the subject has to be recognized as 'Big Science' on the scale of oceanography or biodiversity.

5. Access to large integrated datasets

Many variables and parameters of interest have been gathered in coastal and offshore waters over past decades for commercial and governmental purposes (Fig. 23.5). Some of these data types have been progressively digitized and integrated into consistent national or European data archives. Others are in the early stages of such integration. Other data types are still scattered among regional institutions and commercial companies, although the metadata may have been centralized. Integrated planning for seabed prehistoric research needs to exploit the work that has been done within each specialized discipline to integrate and standardize data with the appropriate quality controls used in that discipline. The degree of data centralization and access varies between countries for some data types, and this will have to be itemized by country.

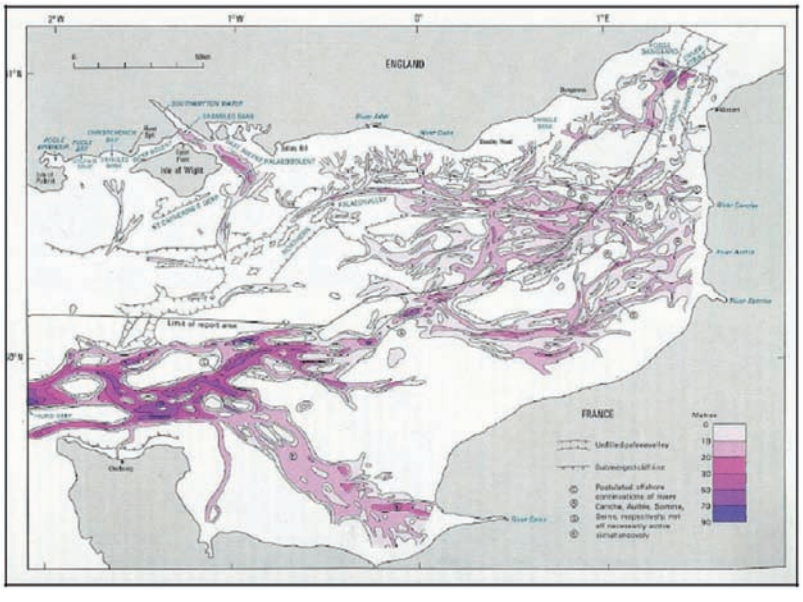
In response to the EU Marine Policy/Strategy Directive initiatives by DG MARE, and parallel initiatives on pan-European electronic data access (DG INFSO), and support for operational oceanography (DG RTD and DG ENTR), there is an effort underway to provide rapid access to maritime data, with uniform ability to interrogate large datasets physically located in many different archives. This work is in progress, and incomplete, and the study of submerged landscapes and prehistoric archaeology will benefit greatly if the concepts of 'palaeolandscape' and 'climate change and sea-level change' are built into the new systems from the start.

The following data types of relevance to seabed prehistoric research are being aggregated and prepared in 2011 by DG MARE as uniform European seabed datasets to be available within one to two years:

1. Bathymetry gridded over the whole maritime basin on a grid of at least a quarter of a minute of longitude and latitude.
2. Bathymetry depth in vector form with isobaths at a scale of at least 1:1,000,000.
3. Depth profiles along tracklines.
4. Multibeam surveys along tracklines.
5. Coastlines.
6. Underwater features such as wrecks, seabed obstructions to trawl fishing, etc.
7. Seabed sediments including rate of sedimentation and thickness, 1:1,000,000.
8. Seafloor geology (age, lithology, origin), 1:1,000,000.
9. Boundaries and faults.
10. Rate of coastal erosion or sedimentation.
11. Geological events and event probabilities (landslides, volcanic eruptions, earthquake epicentres).
12. Seismic profiles.
13. Minerals (including aggregates, oil, and gas).

While the resolution of these merged datasets is still rather coarse for site-specific prehistoric research, they will provide a good framework upon which to patch in high-resolution local models. Over a number of years the resolution

Figure 23.5: During the Pleistocene glacial low sea levels the rivers of the North Sea overflowed the Weald–Artois chalk ridge between southeast England and northwest France, and eroded a major river valley toward the Atlantic. This Channel River was joined by the flow of the Seine, Somme and Arun, and the several rivers discharging into the Solent. The exact pattern varied between the different glaciations. The rivers converge at a major confluence between Cherbourg and the Isle of Wight, and there are substantial Palaeolithic remains on the seabed off both coasts (© British Geological Survey, reproduced by permission)



of each dataset should also be refined as a result of user demand.

Within the timescale of infrastructure development during the SPLASHCOS project, the data managers need to identify all European, national and regional digital repositories (DR) of pre-existing reliable data relevant to Project Deukalion, including geosciences, environmental sciences and cultural heritage sciences, using existing catalogues and directories where possible. From these we can develop a manual of data products and systems available for researchers. Ultimately, it should be feasible to develop an access front system for this range of data, allowing limited or restricted access to datasets that would otherwise be unavailable for commercial or security reasons. Table 23.3 presents a more detailed list of data types, sources of data, and the names of programmes, projects, and agencies holding data of potential interest to SPLASHCOS and Project Deukalion.

6. Collaboration and exchange of data

Seabed prehistoric research has been conducted by single institutions for the last 30 years, but usually only for a few years on a few sites in each case. The exceptions have been the Danish researchers in the southern Baltic, the Israeli studies of submerged sites on the Carmel coast and, more recently, the German studies also in the southern Baltic. Multi-institution and multinational collaboration has gradually increased, and publications have been exchanged in many languages. There is now widespread recognition that the full benefits of research on any one seabed site can only be achieved by an integration of data, at least at the sea basin scale, requiring continuous collaboration and exchange of information electronically. This is fully recognized by the Memorandum of Understanding of the SLASHCOS project, and in the planning for Project Deukalion.

7. Planning and implementation

This is not the place to expatiate on the details of logistics, administration and communications needed to manage the archives, services, and research planning suggested in this chapter. At every level from the single agency to fully funded EC 'research and technology development' pan-European projects, these procedures are well established. There are added levels of complexity in SPLASHCOS and Project Deukalion because of the multiplicity of disciplines and the need for collaboration between agencies, departments, and laboratories that have not previously needed to work together. The progress up to 2011 shows that these problems can be identified and tackled in a logical way, although there will be considerable need for crossover meetings and workshops where different communities get to know one another better and to understand the requirements and limitations of different technologies. This diversity of participation should also extend to include collaboration with industry, and to amateurs and collectors who are often very well informed as to the location of seabed prehistoric remains and the detailed significance of their finds.

8. Strategic review

The organization of infrastructure of data management, planning objectives and collaborative agreements will need to continue for several years, preferably decades, if the full benefits are to be achieved. As new data are gathered, and as new developments occur in other disciplines, dating technology, palaeoanthropology, climate models, etc., the medium and long term goals of Project Deukalion and its successors will need to be modified and revised. The community of institutions and experts involved in the topic is sufficiently strong and flexible to maintain this process in a creative and positive way.

9. Publications and dissemination

A pan-European project to study the prehistory of the continental shelf needs a permanent system of electronic information management, publication, and communication. Technology is developing rapidly, and the system will have to be updated accordingly every few years. The primary output must be academic publications of the highest standard, and these should be produced in parallel with books, reports, popular media, public information, and outreach to volunteers and to the coastal and offshore industries.

Conclusions

A combination of factors justifies the effort to establish a broad infrastructure to support continental shelf prehistoric research on a European scale. The technology and computing power now exist at reasonable cost, and the academic argument for obtaining the field data and analyzing its implications is very strong. Very large quantities of data have been gathered

Data types that are (or are probably) integrated in a standard way, which can be accessed electronically for most European coastal states' sea areas of jurisdiction	
1.	Digitized modern coastline (varied accuracy and resolution). Also ESA and NASA images
2.	Mapping of wetlands and coastal zone (in progress in some countries) ESA/NASA images
3.	Solid geology, seabed outcrop geology at low resolution (scale, level of detail). Typically published by the National Geological Service
4.	Seabed bathymetry, digitized charts (Hydrographic Offices) raw data; variable chart datums, commercial restrictions on high-resolution data. Some very poorly surveyed areas, not resurveyed in 100 years
5.	Seabed sediment classification, map series, digitized maps (examples for North Sea by BGS, Norway, Netherlands, etc.)
Data types for which the metadata have usually been centralized at a European level through EC programmes or at national level. Access to data could be difficult or laborious	
6.	National inventories of monuments, cultural heritage or antiquities, possibly with dedicated sections for coastal, intertidal and marine sites, artefacts, and landscapes
7.	Seabed sediment samples. EU-SEASED, a searchable Internet database of seabed samples and cores held by European geological surveys and research institutes. 300,000 samples listed
8.	EUROCORE, searchable online inventory of seabed cores held in Europe. Many cores have not been analyzed, so this only tells us that they exist. 40,000 cores listed
9.	Swath bathymetry. DG MARE is compiling a total inventory of archived swath bathymetric data, including commercially held data
10.	EUMARSIN. Marine sediment data. Over 140,000 entries
Data types for which access can be obtained to use the data on a case-by-case basis, depending on classification and confidentiality	
11.	3-D acoustic shallow penetration and seismic data. Access for research purposes has been obtained for much North Sea data
12.	Single track seismics and sub-bottom profiling
13.	Commercially held swath bathymetry
14.	Precision bathymetry held on a commercial basis by national hydrographic offices, and marketed
Data types for which there is no known centralized integration at European level	
15.	National or sub-national inventories of submerged prehistoric sites. Major example Denmark, plus the German Baltic coast, possibly Greece. National monuments records that may contain mention of coastal, wetland, or submerged prehistoric sites
16.	Palynology from marine sediments and cores
17.	Foraminifera, beetles, and other indicator species from marine cores
18.	Peat occurrence in marine cores
19.	Radiocarbon or other date calibrations from marine cores and sediment samples
20.	DNA from marine cores and sediment samples
21.	Comparative evaluation of estimates of positions of palaeoshorelines
22.	Palaeo ice cap margins and thickness
Research projects producing models or gridded datasets of interest to Project Deukalion, and which we could not generate (usually) within the project, except at a local or regional level	
23.	INQUA, IGCP, IGBP, PAGES, CLIVAR, STRATEGEM, etc., producing complex multi-variable models of past climate conditions, on global or regional scales
24.	Palaeoceanographic conditions (e.g. PALSEAS, MARGO)
25.	Local and regional sea-level curves
26.	Palaeoisostatic recovery maps/palaeoshorelines (e.g. SINCOS) (Many regional papers by Lambeck, Shennan, Peltier, and others)
27.	Palaeo river valley maps (e.g. Gibbard 1988; Gibbard and Lautridou 2003)
28.	Palaeoclimate reconstructions with seasonal temperature, precipitation, wind speed, etc. (e.g. Van Andel and Davies 2003)
29.	Palaeo ice sheet reconstruction, date, ice margins.

This list provides guidance to the numerous agencies, programmes, and projects that have been active in the field during the last decade. The technicalities are not easy, and the range of types needs to be brought to the attention of as many specialists as possible. Acronyms: BGS British Geological Survey; CLIVAR Climate Variability and Predictability programme; DG MARE European Commission Directorate-General for Maritime Affairs and Fisheries; EC European Commission; EMODNET European Marine Observation and Data Network; ESA European Space Agency; EUMARSIN European Marine Sediment Information Network; EUROCORE European Marine Core Inventory; EU-SEASED European Seabed Sediment Inventory; IGBP International Geosphere–Biosphere Programme; IGCP International Geological Correlation Programme; INQUA International Union for Quaternary Research; MARGO Multiproxy Approach for the Reconstruction of the Glacial Ocean Surface; NASA National Aeronautics and Space Agency; PAGES Past Global Changes; PALSEAS Palaeo Sea Level Working Group; SINCOS Sinking Coasts (of the Baltic); STRATEGEM Stratigraphical Development of the Glaciated European Margin

Table 23.3: Data types in Europe needing consideration

from the continental shelf by other disciplines and industries, and these archives can be searched and linked to provide a permanent service underpinning the environmental aspects of Late Pleistocene prehistory. Experienced personnel exist in all European coastal states interested in this topic, and their institutions have expressed interest and support for European collaboration.

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24

Stone Age on the Continental Shelf: an eroding resource

Anders Fischer

The world lost vast parts of its habitable territory owing to rising sea level during the Late Glacial and the Early Holocene. The archaeological record and our knowledge of early prehistory must, therefore, be considered highly biased and fragmentary as long as large and unique parts of it lay unexplored on the continental shelf. This chapter outlines the special character of this scientific resource in comparison to archaeological material from present-day dry land. Special emphasis is placed on the archaeological evidence from the western Baltic, and a summary of the approaches responsible for the relatively rich record of inundated Stone Age sites known from this region is presented. The ensuing discussion focuses on the current problem of seabed erosion, which is threatening to destroy significant parts of the prehistoric cultural heritage that has been preserved for millennia in the Baltic and possibly other shallow water areas around the world. Suggestions and considerations for the management and exploration of submerged sites are presented.

Keywords: erosion, eelgrass, settlements, fishing weirs, heritage management, Palaeolithic, Mesolithic, Neolithic

Introduction

Vast areas of habitable land were flooded when the ice sheets of the Last Glaciation melted. The present chapter deals with the archaeological heritage that was submerged during this long-lasting event, which took place during the latter half of the Upper Palaeolithic, the whole of the Mesolithic, and parts of the Neolithic.

Traces of human activity in the now-submerged lowlands were not totally erased by the rising sea. Archaeological investigations in the western Baltic (Danish, southern Swedish, and northeastern German waters) have demonstrated the existence of numerous settlements in the seabed. In some cases, the preservation of these cultural deposits exceeds what can be found above present sea level. Scattered observations indicate that similar sites exist in several other places on the continental shelf of Europe and other parts of the world (e.g. Flemming 1983, 2004, this volume; Verhart 1995; Faught and Gusick, this volume; Galili and Rosen, this volume; Nymoen and Skar, this volume).

There is good reason for prehistorians and heritage agencies to be concerned about the submerged Stone Age. In early prehistoric times the drowned lowlands and waterfronts of the present-day seafloor surely hosted some of the highest concentrations of human population. Their generally very fertile soils presented particularly attractive territories to Stone Age hunters, gatherers and early farmers, and these areas were bordered by the most productive environments for fishing and shellfish collection. Since transportation by boat was essential at least as far back as the Pleistocene–Holocene transition, *c.* 10,000 BP/9600 cal BC, these landscapes must also have served as effective corridors for movements and dispersal of populations and information (Fischer 1995c,

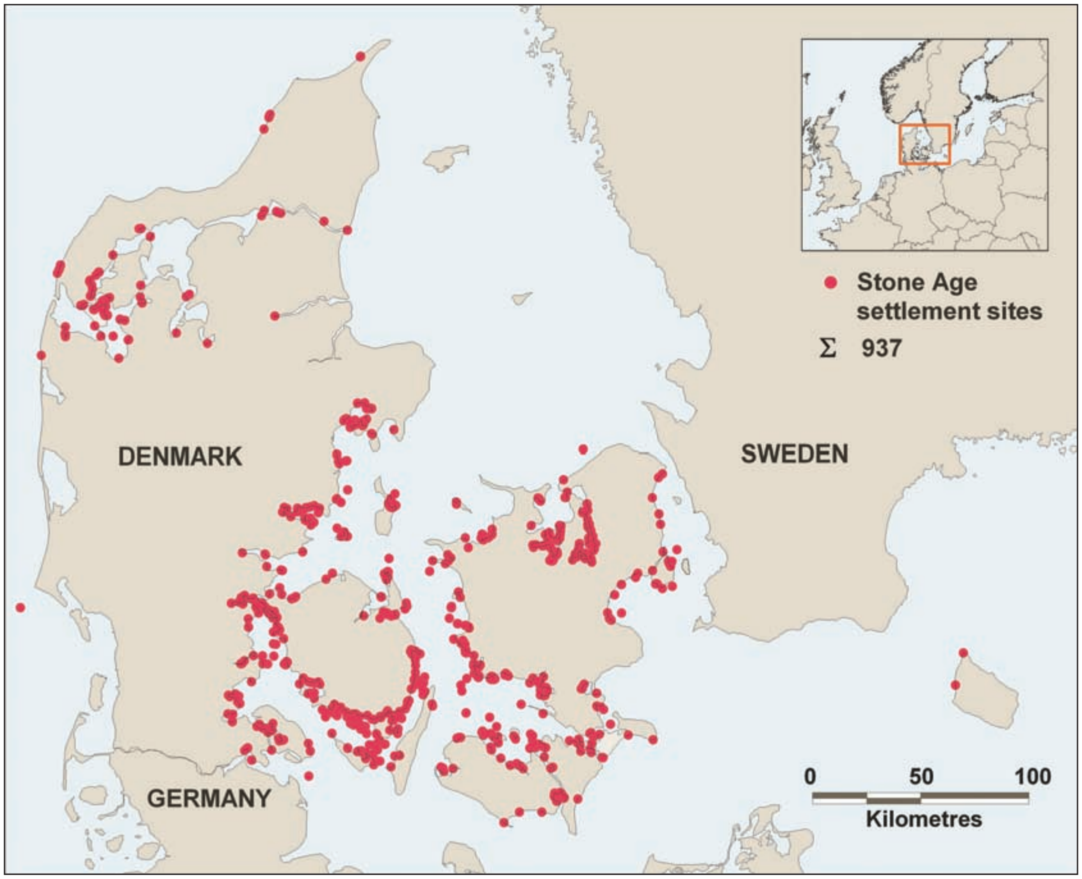

Figure 24.1: Stone Age settlements from the Danish seafloor (Drawn by Claus Dam, Heritage Agency of Denmark)

1996; Mulvaney and Kamminga 1999: 103–12; Flood 2001: 27–38; Bailey 2004; Fischer and Hansen 2005).

Consequently, previous syntheses of human prehistory, based almost exclusively on the highly fragmentary and biased archaeological evidence from present-day terrestrial sites, must be considered fragmentary, and looked at with appropriate scepticism. Aimed at a comprehensive understanding of early human lifeways, population histories, and cultural evolution on continental or global scales, the international research community must encourage systematic archaeological fieldwork on the now-submerged continental shelf.

Stone Age finds from the western Baltic

The great rise in sea level during the Late Pleistocene and Holocene most certainly did not erase all evidence of human activity in the now inundated Baltic lowlands. This is seen from the sheer number of Stone Age settlements known from the Danish seafloor (Fig. 24.1).

Most of the sites recorded in the western Baltic have only yielded information about finds of worked flint that were washed out of their original sediment (e.g. Larsson 1983; Fischer 1993a, 1993b). However, when such sites are test-excavated, it frequently shows up that at least parts of their original culture layers still exist *in situ* (Fig. 24.2). Some of them contain extensive cultural layers where specimens of bone and wood are often well preserved (Andersen 1985, 2009; Fischer *et al.* 1987; Fischer 1992; Grøn 1995; Lübke and Hartz 1995; Skaarup 1995; Sørensen 1996; Lotz 2000, 2008; Dal 2002; Lübke 2004; Skaarup and Grøn 2004; Fischer and Hansen 2005).

In general, the current record of Stone Age cultural heritage in the western Baltic consists of:

1. Settlements – most of these represent Mesolithic coastal habitation, and the better-preserved examples often include remains of graves, hearths, dugout canoes, and small wooden fish weirs (Andersen 1987, 2009; Fischer 1987, 1995b, 1997b; Dencker 1992; Lübke 2003; Skaarup and Grøn 2004; Fischer *et al.* 2007a).

Figure 24.2: Organic remains such as red deer antler, oak husk, bark, and hazel sticks exposed by erosion in water-deposited parts of the Middle Mesolithic Rønstenen site, Denmark (Photo: Torben Malm)

2. Solitary, large, stationary wooden fishing constructions. Only a few of them have been examined by archaeologists and they all belong to the Neolithic (Pedersen 1997; Fischer 2007; Prangsgaard 2009).
3. Isolated finds of Mesolithic and Neolithic implements such as harpoon heads and fish-hooks (Fischer and Sørensen 1983; Andersen 1995, 1997), which were probably lost accidentally during offshore activities.
4. Items of symbolic value deliberately deposited in the sea as part of votive activity (Fischer and Sørensen 1983; Fischer 1997a, 2004a). Neolithic artefacts of this kind are found clustered in specific fjord locations. They have typically been collected by non-professionals during industrial extraction of raw materials. From the similar dates and artefact types these can be interpreted as marine parallels for Neolithic votive sites in North European bogs, lakes and rivers (cf. Rech 1979; Davidsen 1983; Karsten 1994; Koch 1998; Fischer 2004b).

Rather little field information exists from the latter two categories. Therefore, only settlements and fishing structures will be discussed in the following sections.

Settlements

Submerged Stone Age habitation sites, in astonishing numbers and quality, have been revealed on the western Baltic seafloor since the late 1970s. Most of them belong to the Mesolithic, but there are also examples of Upper Palaeolithic and Neolithic sites. Presently, sites rich in organic remains are only known from areas no deeper than 10 m below present sea level along the southern Swedish, Danish, and northeastern German coasts, which are characterized by a normal tidal range of only a couple of decimetres. It is possible that similar archaeological potential exists in many other shallow areas of the continental shelf around the world. It is also likely that numerous coastal habitation sites with well-preserved organic material (e.g. wooden artefacts and food remains) exist further down the largely unexplored slopes of the seafloor in the western Baltic region and beyond (Fischer 1995b).

The Tybrind Vig site is probably one of the best-known examples of a submerged Stone Age settlement characterized by a rich and varied assemblage of well-preserved organic remains, such as:

- textiles (Andersen 1985);
- wooden items such as paddle blades with artistic decorations (Andersen 1987, this volume);
- human bones, including intact graves (Andersen 1984, 1985; Dahl 2004; Fischer *et al*. 2007b; Uldum, this volume);
- animal bones (Trolle-Lassen 1984), plant food remains (Kubiak-Martens 1999), and residues of charred food on pottery (Andersen and Malmros 1985; Craig *et al*. 2007);
- artefacts of bone and antler (Andersen 1985; Fig. 24.3).

Figure 24.3: Example of organic remains from the Late Mesolithic settlement site of Tybrind Vig: a fish-hook of bone with its string of lime bast still attached to it in the form of a clove hitch (Courtesy of Søren H. Andersen)

Much of the precious archaeological material from Tybrind Vig has been uncovered by seafloor erosion, and was salvaged simply by collecting exposed material as it was about to be displaced by currents and waves.

The pioneering fieldwork on the Tybrind Vig site has produced fundamentally new evidence on Late Mesolithic art, woodworking technology, food, and cooking. Other inundated Middle and Late Mesolithic settlements of similar character, composition, and preservation quality are known from various locations throughout the western Baltic. At present, however, only three of them have been systematically examined and published (Sørensen 1996; Skaarup and Grøn 2004; Andersen 2009) while other sites are currently in the initial stages of recording and research. Most alarmingly, several of them – including most of those with the very best preservation of organic remains – are rapidly being destroyed as the seabed is eroded. This destruction process (Fig. 24.4) has been observed in many places in the western Baltic. When the Tybrind Vig site was first visited in the mid-1970s the process had reached a situation comparable to the early part of stage 4 (Fig. 24.4, stage 4), and in 2009 it was reported to be in the final stage of destruction (Fig. 24.4, stage 5; Torben Malm and Hans Dal, pers. comm. 2009).

The excavation of a geographically, topographically, functionally, and chronologically diverse assemblage of submerged sites with numerous organic remains would greatly broaden the scientific understanding of early prehistory. This is not due only to their special preservation quality, but equally because such habitation areas potentially include the unique and important coastal and estuarine aspect of early prehistory. In most parts of the world direct evidence of this component of ancient human adaptation cannot be found *above* water (Late Upper Palaeolithic and Early Mesolithic finds from raised shorelines in western Sweden and Norway are probably the best explored exceptions to this pattern [Fischer 1995a; Bjerck 2009]).

The global existence and importance of early human coastal adaptation is indicated by the rich array of inland finds of marine shells, bones of marine animals, human bones with marine δ^{13}C values, etc., extending far back into the Palaeolithic (Cleyet-Merle and Madelaine 1995; Fischer 1996; Aldhouse-Green and Pettitt 1998; Stiner 1999; Henshilwood *et al.* 2001; Pettitt *et al.* 2003; Balme and Morse 2006). These can

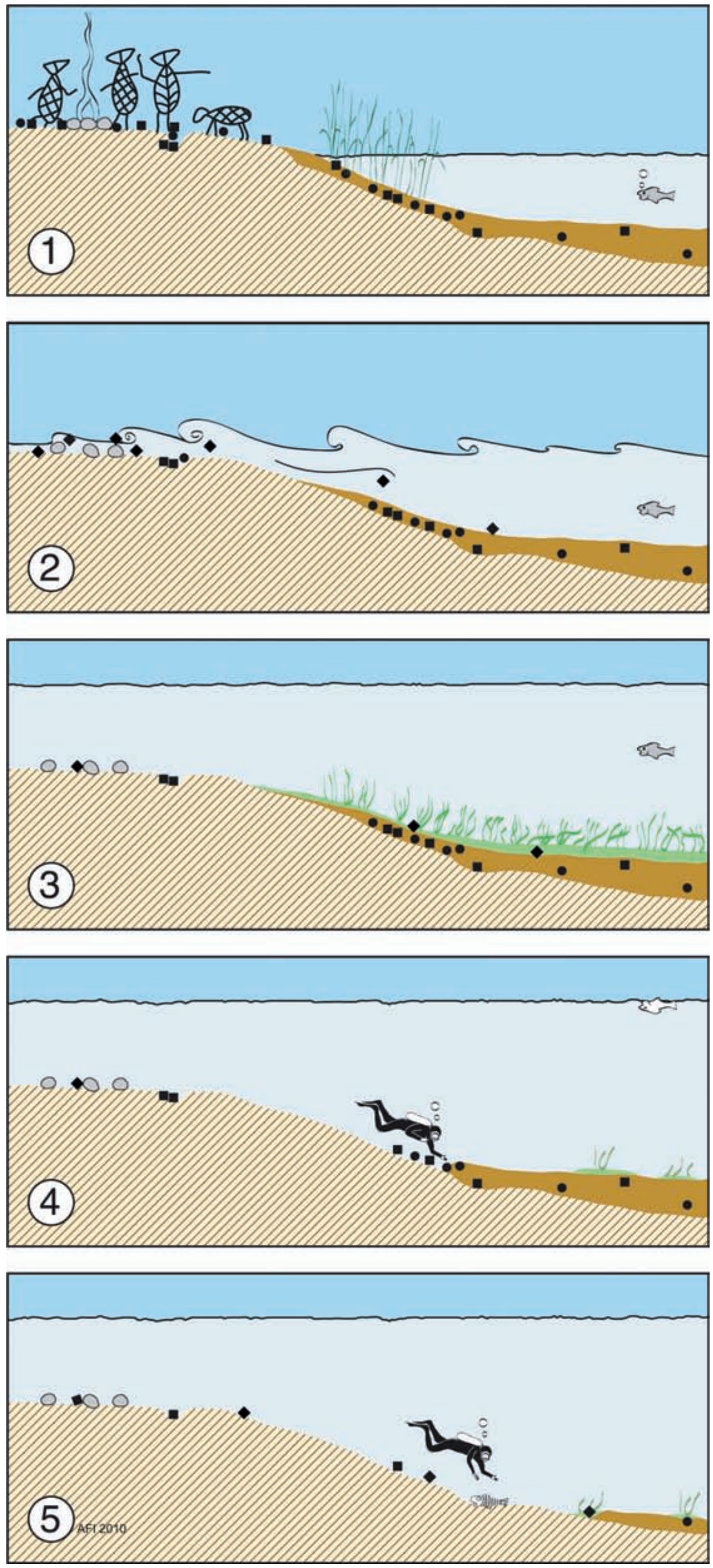

Figure 24.4: Generalized description of the formation and subsequent destruction by erosion of Mesolithic coastal settlements in the western Baltic. While stage 3 has lasted for millennia, stage 4 can take place over just a few years (Redrawn and adapted from Malm 1995 and Fischer 2001)

be considered proxy data for early prehistoric coastal activity and provide valuable inspiration for future attempts to locate and excavate traces of human settlement along submerged shorelines worldwide.

Fish weirs

Remains of Mesolithic fish weirs made of wood are frequently found *in situ* in shallow water deposits along the coasts of the western Baltic (Pedersen 1995, 1997; Fischer 2007; Goldhammer 2008: 72–3). In addition, re-deposited and more or less fragmented rods and sticks from such constructions are found in great numbers together with domestic debris in shallow water marine deposits near many Mesolithic coastal habitation sites (e.g. Andersen 1995, 2009; Myrhøj and Willemoes 1997; Skaarup and Grøn 2004).

More impressive, and generally better preserved, are the remains of Neolithic stationary wooden fishing devices (e.g. Fig. 24.5). Finds of this kind are reported from marine as well as freshwater environments in Northern and Western Europe (e.g. Loze 1988; Lübke and Hartz 1995; Pedersen 1995, 1997; Bulten *et al.* 2002; Prangsgaard 2009; Leineweber *et al.*, this volume).

Figure 24.5: A vertical post with chop marks from a stone axe, surfaced from a Neolithic fish weir at Oreby Rende, Denmark (Photo: Anders Fischer)

The Nekselø site in Denmark is one of the most spectacular of these Neolithic structures. It is the remains of a wooden construction, repeatedly rebuilt over several centuries, originally covering a length of at least 400 m. During the period when this structure was in use, it reached out to a water depth of 4–5 m (Fischer 2006, 2007). Thanks to rapid deposition of marine gyttja during the use period of this weir thousands of poles and numerous parts of wattle constructions were embedded and preserved in the seabed. However, the present-day circumstances of seafloor erosion mean that the wood constructions are gradually being exposed and destroyed (Figs 24.8 and 24.10).

The Neolithic fish weirs found along the coasts of the Baltic indicate that marine fish were caught and consumed in quantities far exceeding what had previously been inferred based on archaeological material from terrestrial sites above present sea level. In addition, these finds have resulted in important information on prehistoric forest management and woodworking (Christensen 1997; Pedersen 1997).

Locating sites

Locating submerged Stone Age sites in Danish waters has been based on a series of complementary approaches. Among these are:

- searching museum stores and archives for previous finds and observations;
- interviewing sport divers, fishermen, and other people familiar with the marine environment;
- developing topographic models of site location;
- conducting underwater contract archaeology;
- running systematic underwater reconnaissance expeditions;
- receiving find reports from individual amateur archaeologists and sport divers;
- training and maintaining contact with diving clubs and individual sport divers.

Sport divers with an interest in archaeology play a central role in the success of Danish underwater surveys and research excavations. This is partly the result of a programme of classroom seminars and field schools, which includes teaching sport divers what to look for, how to distinguish 'look-alikes' from actual worked flint, how to handle waterlogged prehistoric wood, and so forth. As a result, some of these non-professionals have become impressively good field archaeologists.

The erosion problem

Threats to the inundated heritage

Various destructive forces threaten the cultural heritage of the seabed, including:

- raw material dredging;
- construction;
- trawl fishing;
- mollusc scraping;
- turbulence from boat/ship traffic;
- erosion following decline in seafloor vegetation.

The first five of these menaces are familiar to most underwater archaeologists and to some degree are already considered and managed by national heritage agencies. This chapter will, therefore, focus primarily on the last-mentioned cause of destruction – erosion resulting from the disappearance of seafloor vegetation. This threat currently impacts vast areas rich in cultural heritage; however, its effects are not yet widely recognized among archaeologists.

Erosion and eelgrass death

Monitoring of a number of submerged Danish Mesolithic settlements (Malm 1995; Lotz 2000, 2008; Dal 2002, 2008) and the Neolithic Nekselø fish weir (Fischer 2006, 2007; cf. Pedersen 1995) over several decades demonstrates a clear connection between the decline of local eelgrass vegetation and rapid erosion of cultural heritage. Soft sediments of gyttja and sand that had been stable since they were deposited in the Stone Age have now disappeared, and the cultural heritage hitherto embedded and protected in these sediments has washed away.

Eelgrass (*Zostera marina* L.) and related seagrasses cover wide stretches of the seabed along the coasts around the world, especially in areas where the bottom is composed of sand or mud (Rasmussen 1977; Short and Wyllie-Echeverria 1996; Boström *et al.* 2003; Borum *et al.* 2004). Today, eelgrass meadows are generally found in Danish waters at depths of 1–6 m (Hjorth and Josefson 2010). In dense patches, the long green shoots of the plant, which can reach a height of more than a metre, significantly reduce currents and water turbulence. Moreover, the system of roots and belowground stems (rhizomes, cf. Fig. 24.7) of this species forms a tightly knit mesh, which has a considerable effect in keeping sand and detritus fixed. Eelgrass meadows, therefore, effectively protect deeper lying sediments, cultural layers, and prehistoric constructions from erosion by wave action and currents.

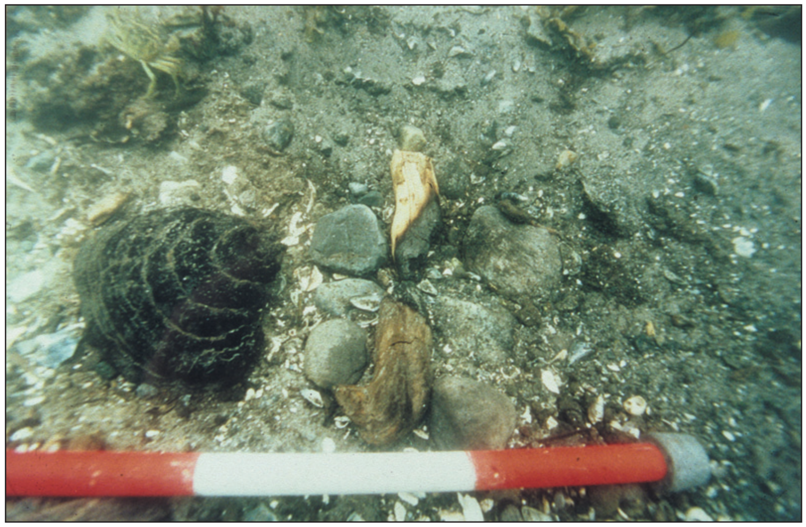

Figure 24.6: A hearth revealed by erosion at the Late Mesolithic site of Ronæs Skov, Denmark. It consisted of a stone pavement on top of which were two partially charred pieces of wood. A tinder fungus was still in situ *immediately adjacent to the feature. The white part of the measuring-stick is 20 cm long (Photo: Hans Dal)*

Around AD 1900, eelgrass meadows were reported to have flourished to depths of 11–17 m in Danish waters (Ostenfeld 1908; Krause-Jensen and Rasmussen 2009) and covered about one-seventh of all Danish marine waters (Petersen 1914). The subsequent decline in the extent and density of eelgrass vegetation in Denmark seems to have three causes. One of them may be seen as natural, while the other two are clearly the result of changes in the ecology of coastal waters caused by human impact:

1. In the 1930s the 'wasting disease' decimated Danish and North Atlantic eelgrass meadows, and this vegetation did not return in considerable amounts until the 1950s and 1960s (Rasmussen 1977).
2. Owing to reduced penetration of sunlight, however, eelgrass has not been able to recolonize the whole of the territory lost in the 1930s. The

Figure 24.7: Eelgrass death at the Tybrind Vig site (Photo: Torben Malm)

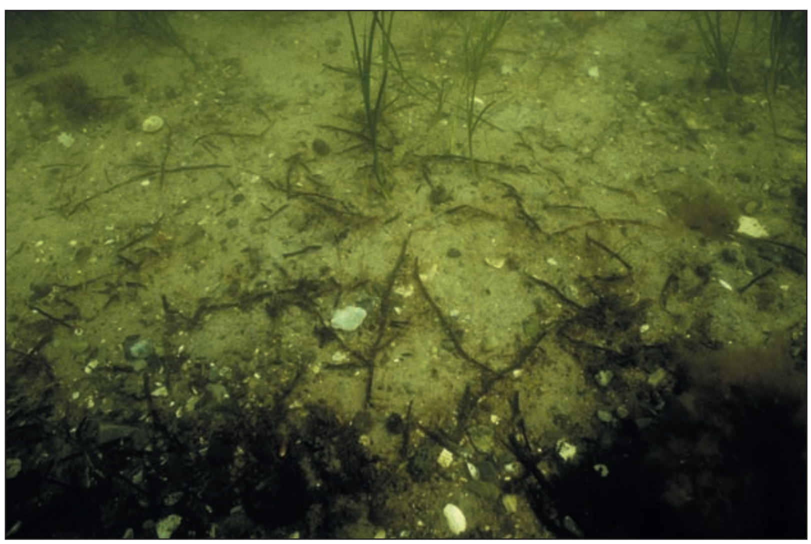

Figure 24.8: Erosion of a Neolithic wattle construction at the Nekselø site (Photo: Anders Fischer)

shading of the seafloor over the later decades is mainly the result of more phytoplankton in the water column, caused by discharge of nutrients, primarily nitrogen washed in from the intensively fertilized farmlands of the region (Rask *et al*. 2000; Duarte *et al*. 2004; Krause-Jensen *et al*. 2008).

3. Even in areas of the western Baltic, where the penetration of sunlight is sufficient for the growth of eelgrass, this species has suffered severely during recent decades. In some summers this vegetation has actually vanished from huge areas. Apparently, the widespread eelgrass death is linked to events of anoxia in the water column with associated emission of hydrogen sulphide, which is toxic to the plant (Rask *et al*. 2000; Duarte *et al*. 2004; Greve and Bintzer 2004).

Periods of anaerobic bottom water have occurred frequently in the western Baltic over recent years primarily as a result of decay of dead micro- and macroalgae during the warm seasons. The most severe cases have appeared during periods characterized by a combination of the following three situations:

- unusual amounts of rain, resulting in relatively high discharge of agricultural nutrients into the marine environment and a bloom of algae with short lifespans;
- relatively high summer water temperatures that stimulate microbial decomposition of dead algae, and result in depletion of oxygen in the marine environment;
- calm winds, resulting in reduced mixing and aeration of water masses and further acceleration of oxygen depletion.

Combinations of the first two climatic conditions are predicted to become more common in the western Baltic region due to global warming (Danish Metrological Institute 2010), and the third condition will most likely occur at a frequency comparable to the present situation.

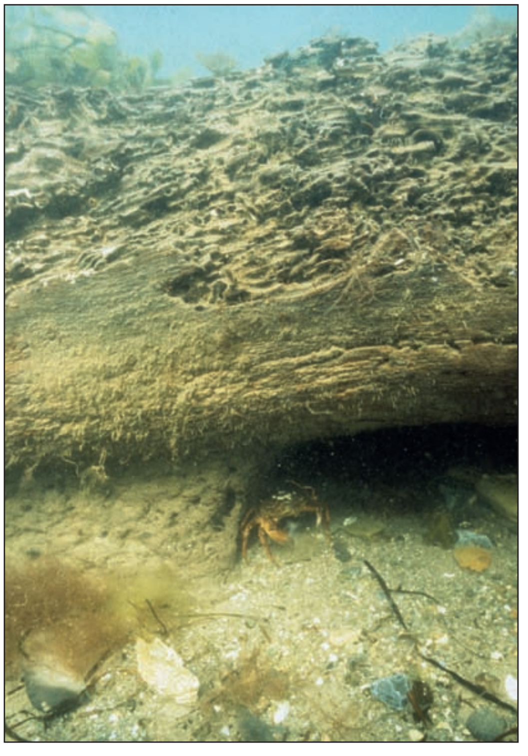

Figure 24.9: Close-up of a 0.5 m thick Mesolithic oak trunk at the Tudse Hage site, which has fallen prey to shipworms following the disappearance of its former cover of eelgrass and gyttja (Photo: Torben Malm)

Therefore, climate change may be added to the list of destructive forces that will potentially contribute to the loss of cultural heritage hitherto preserved in the seabed. On the other hand, political concern for restoring the ecological balance of the aquatic environments will, hopefully, reduce this threat.

Biological destruction following erosion exposure

As soon as prehistoric remains of organic material are exposed through erosion they are likely to fall prey to various biological decomposition processes, which will inevitably result in their total destruction (Gregory 1997, 2001, 2009). This, for instance, applies to the numerous submerged stumps and fallen trunks of prehistoric trees in the western Baltic that have been exposed by seafloor erosion over recent years. When the wood is no longer covered by sediment it is attacked by shipworms, which can destroy even huge trunks of hardwood within a couple of decades (Fig. 24.9).

Piddocks (Pholadidae) are another cause of

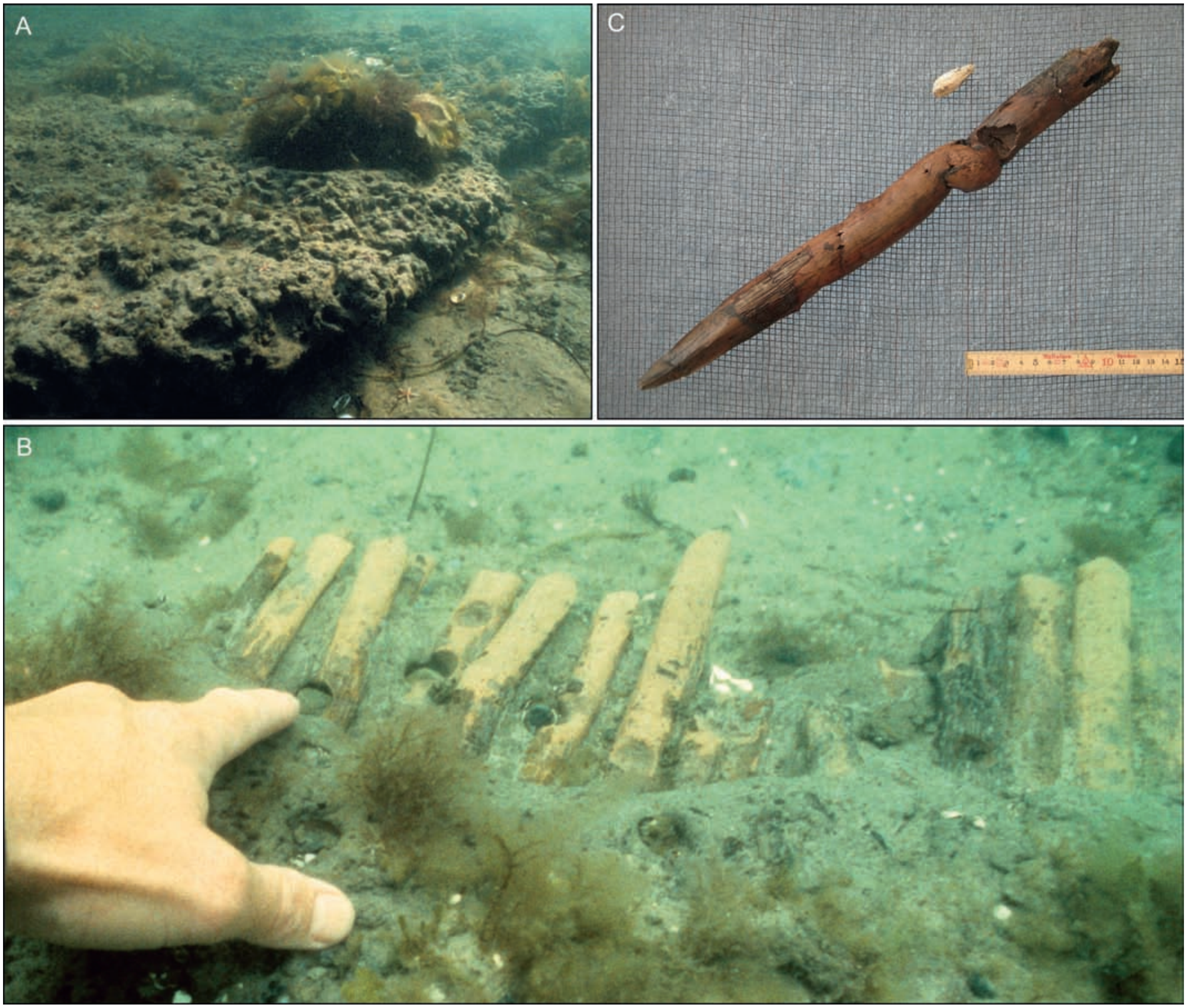

Figure 24.10: Seafloor erosion and piddock holes at the Nekselø site. A: Clay gyttja exposed by erosion and pitted like Swiss cheese from an attack by piddocks. The erosion face is 0.4 m high. B: Horizontal erosion surface with vertical piddock holes, some of which penetrate hazel rods from a Neolithic wattle screen. C: Before its excavation this hazel rod stood vertically in the gyttja with the pointed end facing downwards. A piddock (the 'teeth' of which are seen to the left in the photo) had worked its way vertically down through the rod, until the hole had grown so wide that it broke the wood surface near the top end of the sample (Photos: Anders Fischer)

destruction of soft cultural and natural specimens in the top of the western Baltic seafloor – and probably in many other marine environments around the world. These organisms drill vertical holes up to 2 cm wide and 20 cm deep into wood – and into gyttja surrounding the wood (Fig. 24.10). Worms, clams, crabs, lobsters and fungi also contribute effectively to the penetration, disintegration, and decomposition of recently exposed marine sediments and artefacts of organic materials (Momber 2004; Dal 2008).

A global problem?

Discharge of nutrients into coastal waters is presently taking place in most shallow marine waters close to densely populated or intensely farmed areas worldwide. Vast parts of these stretches of seafloor have, until recently, been covered by dense stands of seagrasses reaching as deep as at least 43 m in marine regions with highly transparent waters (Duarte *et al.* 2007; cf. Duarte 1991, mentioning examples of even deeper colonization depth). Recent biological reports from around the world suggest widespread and accelerating devastation of these underwater meadows (Short and Wyllie-Echeverria 1996; Krause-Jensen *et al.* 2004; Orth *et al.* 2006; Waycott *et al.* 2009). Based on the archaeological observations from the western Baltic, the warning should therefore be expressed that seafloor erosion and massive destruction of submerged early prehistoric cultural heritage may presently be occurring on the continental shelf worldwide.

Coping with erosion

Protective constructions will be, in some cases, effective and recommended heritage management responses in the face of seafloor erosion. Such measures have so far only been taken on a very modest scale at submerged Stone Age sites.

Figure 24.11: What is likely a short-lived attempt at stopping erosional destruction of the Nekselø fish weir. A small part of the feature is covered by fibertex and sand bags (Photo: Torben Malm)

Small areas of the Tybrind Vig and Nekselø sites have been wrapped in *fibertex* and covered with bags of woven plastic fibres filled with gravel (Malm 1995; Fig. 24.11). Inspections of these installations after four and six years, respectively, proved these protective measures to be generally effective. In the longer term, however, there is no doubt that sandbags will disintegrate. Even if the protective constructions were made of more durable materials, it is likely that erosion would eventually undermine the installations.

In many places protective installations will not be technically, economically, or practically adequate solutions to the problems of the eroding underwater cultural heritage. Salvage excavation can be considered an optimal approach taken by conscientious heritage managers in such cases. If the necessary staff and funding for such rescue archaeology cannot be procured, diving inspection of vanishing sites by means of professionals or professionally supervised sport divers, for the purpose of collecting scientifically valuable artefacts and recording observations of research interest, could be a low-cost alternative. The Danish Heritage Agency promotes all three approaches, but has only a modest budget to support such fieldwork. The lack of resources does not seem to be better in the Swedish and German parts of the western Baltic (cf. Lüth 2003). The primary concern, however, is the current lack of resources for systematic underwater field reconnaissance. This situation implies that, over a short span of years, many sites rich in research potential will probably vanish from the western Baltic without any archaeological recording or attention.

Consequently, there is an immediate need throughout the western Baltic for a concerted effort to locate prehistoric sites and secure their archaeological evidence before it is lost forever. The same situation likely also characterizes many other parts of the continental shelf of Europe and beyond, where surveying for early prehistoric remains is still in its infancy.

Conclusions

The available archaeological evidence of the submerged Stone Age world below the seas is very dispersed and fragmentary. The geographically uneven distribution of the observations is likely to be changed considerably by future systematic underwater surveys.

The international research community has already passed the threshold where it possesses sufficient practical experience and technological competence to go directly into action – provided the resources needed are made available. It is therefore time to make the transition from academic speculation to active field research. Based on the experiences from the western Baltic the following two approaches can be recommended:

1. Immediately initiating diving surveys of hitherto unexplored parts of the seafloor, which – according to existing cartographic data, predictive models and/or stray finds – already appear promising for underwater prehistoric archaeology ('the fast-and-adventurous approach').
2. Systematically building up an integrated bank of archaeological, bathymetric, sedimentological, and taphonomic data for the designation and subsequent inspection of areas of special interest for underwater prehistoric field archaeology ('the slow-and-safe approach').

Preferably, the two approaches should be employed to complement one another owing to their potential for mutual correction and inspiration. Initiatives in this direction will benefit from cooperation between many nations, organizations, and research disciplines. Given that significant areas of the submerged continental shelf, representing a vast and important cultural resource concerned with early human history, are currently threatened by rapid destruction, the time is right for national as well as international initiatives of this kind.

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25

Continental Shelf Archaeology: where next?

Geoffrey N. Bailey

Until very recently the case for systematic exploration of the now submerged landscapes of the continental shelf was taken seriously by rather few mainstream archaeologists, and advocacy in support of underwater prehistory was usually regarded as evidence of enthusiasm for diving, hopeless optimism with regard to the prospects of discovering useful information, or indulgence in fanciful speculation. Developments in the technology of underwater exploration, the steady accumulation of finds, the quality of preservation of organic materials, and above all the realization that coastal regions for most of human prehistory are now submerged and most likely played a key role in many of the most important developments in prehistory, are slowly shifting the climate of opinion. The question now is not whether we should undertake underwater exploration, but how we should go about it. Here, there are still powerful inhibitions and uncertainties, especially when it comes to the deeper areas of the shelf and to the systematic discovery of archaeological sites. Large-scale international collaboration, engagement with industrial and commercial partners, development of purposeful and realistic strategies of exploration, a new and growing generation of trained practitioners, an expanding knowledge base about the taphonomy of underwater landscapes and archaeological remains, and the progressive extension of experience from land to shallow water, and from shallow to deeper water, are all foreseeable ingredients of the next phase of investigation.

Keywords: coastlines, Farasan Islands, Gibraltar, Red Sea, shell mounds, underwater archaeology

Introduction

The publication of this volume, and the organization of the conference session that gave rise to it, are evidence of a broad and growing shift of opinion within archaeology about the desirability and viability of undertaking systematic exploration of the submerged landscapes of the continental shelf drowned by sea-level rise at the end of the Last Glacial. Indeed, the acceleration of interest within the past decade in the possibilities of such work and the desirability of carrying it out has been quite dramatic. There is, however, a difference between stating that something is desirable, and actually acting on that motivation, let alone achieving the hoped for results. There remains at the present time quite a large gap between aspiration and achievement, and probably quite a long period of exploration and experimentation still ahead of us before we can talk about approaching the full realization of an integrated discipline dedicated to the submerged prehistoric archaeology and landscapes created when sea levels were lower than the present, or continental shelf archaeology (hereafter CSA). The aim of this paper is to summarize the steps in my own conversion to the cause of CSA, to review the intellectual case for promoting it, and to evaluate the problems and possibilities of realistic engagement and the strategies for dealing with them, using recent fieldwork in the Farasan Islands and Gibraltar as a basis for discussion.

Background

Like many archaeologists interested in coastal prehistory, my awareness of the problem created by sea-level change, that most coastal sites and shell middens pre-dating the Middle Holocene would most likely be submerged or destroyed because of sea-level rise at the end of the Last Glacial period, has a long history, in my case going back to the beginnings of my research career. A key factor in my own thinking was the growing body of evidence for a sea-level regression of at least 100 m during the Last Glacial Maximum and its likely impact on the visibility of coastal shell middens or other archaeological evidence for the use of Pleistocene coastlines. In the 1970s, there were still considerable gaps in our understanding of sea-level change and ongoing speculation about possible high sea-level stands within the Last Glacial. The demonstration that oxygen isotope ratios in deep-sea cores provide a direct measure of changing ice volumes and therefore by definition a sea-level curve, marked a significant step toward an agreed eustatic sea-level curve of universal applicability, although there were still uncertainties about sources of error and the correlation of isotope ratios with sea-level depths (Shackleton 1967, 1977; Shackleton and Opdyke 1973). Another significant landmark was the La Jolla conference organized by Pat Masters and Nic Flemming in 1981 (Masters and Flemming 1983a), at which there was extensive discussion and optimism about the prospects for moving the discipline forward and mounting sustained investigations of the submerged shelf, deploying a range of techniques and technologies from a variety of disciplines. It is symptomatic of the barriers and inhibitions to this type of research, especially the high costs of conducting underwater investigations and the high ratio of intellectual risk to reward, that, in spite of the growth in the number of finds and systematic underwater archaeological excavations in certain key regions, the integration of the results into the mainstream of archaeological interpretation has been relatively slow, and their impact on the broader narrative of world prehistory quite limited.

Like many then and since, I had no clear view about the viability of direct underwater exploration, no practical knowledge of how to go about it, and little information with which to judge the effects of sea-level rise on the survival or visibility of archaeological deposits, in spite of an optimistic assertion that conditions might exist in which substantial midden deposits could survive inundation and be accessible to discovery (Bailey 1983; Masters and Flemming 1983b). Also, not being a diver or a sailor, I had little inclination to dip my toe, literally or metaphorically, into these uncharted waters. Moreover, the archaeological application of remote sensing techniques to the reconstruction of submerged landscapes using acoustic survey and underwater vehicles was still in its infancy. Most of my analysis of the problem was confined to demonstrating the changes in the visibility of evidence for shell gathering, marine resource exploitation, and maritime activity generally, which must result from changes in sea-level. Even that simple point was open to challenge by large sections of archaeological opinion that wanted to see in the explosion of Middle Holocene evidence of coastal activity an indicator of population growth and intensification, rather than the effect of increased visibility of evidence following stabilization of sea level. Both sides of this argument remained stalled by negative evidence: I could not prove that Upper Palaeolithic or earlier coastal shell middens existed and awaited discovery 20 m or more beneath the sea, and those who opposed that view could not disprove that possibility.

My interest in the problem received further impetus with the culmination of the Klithi project in northwest Greece (Bailey 1997a). Dedicated to investigating the wider landscape context of human activity in the region throughout the Palaeolithic sequence, one of the main outcomes of that project was to point to the extensive and now submerged areas of coastal territory as most probably the main regional focus of human settlement and activity: '… one of our greatest areas of ignorance, and one of the greatest challenges to future research' (Bailey 1997b: 674). We considered the possibilities of offshore exploration in that project, but further development of these ideas was halted by a variety of inauspicious circumstances and changing political conditions, including the heightened security risks of operating in Greek waters close to the Albanian border in the early 1990s.

Resumption of new research on coastal shell middens in Europe and the coastal factor in early human dispersals (Bailey and Milner 2002; Flemming *et al.* 2003; Milner *et al.* 2007) led to a further articulation of the case for the likely importance of coastal environments and marine resources in the deeper time ranges of human prehistory, and highlighted the need for under-

water exploration (Bailey 2004a, 2004b; see also Erlandson 2001; Erlandson and Fitzpatrick 2006). From 2004 onwards, new field research in the Saudi Arabian sector of the southern Red Sea and offshore of the Neanderthal caves in Gibraltar provided an opportunity to experiment with underwater exploration as part of more broadly based investigations of coastal archaeology in these regions, which is still ongoing (Bailey *et al*. 2007a, 2007b, 2008, in press; Bailey 2009, 2010; Alsharekh *et al*., in press). In the past 20 years there has also been rapid development and deployment of technologies for underwater survey, driven in large part by the expansion of industrial activity on the seabed, which have transformed the potential for underwater work. It is not my purpose in this chapter to give a detailed account of the offshore work that we have conducted in the Red Sea or Gibraltar, but I will refer to that work as a source of reflection about the current state of CSA.

What are we missing?

What difference would it make to our understanding of human prehistory if archaeological and palaeoenvironmental evidence from periods of lower sea level were preserved underwater and could be systematically investigated? What are we missing by not engaging with the exploration of CSA?

The case for the survival of evidence underwater and the general methods available for its investigation is made at length elsewhere (Fischer 1995a; Flemming 1998, 2004; Bailey and Flemming 2008; Ballard 2008; Gaffney *et al*. 2009; chapters in this volume). Suffice it to say here that enough investigations have now been carried out to show that archaeological sites can survive inundation, sometimes in great numbers and with excellent preservation of organic materials. In favoured conditions, as in the calm and shallow waters of Denmark and northern Germany, underwater investigation has revealed whole categories of evidence that would not occur on land, or would only rarely be preserved in terrestrial deposits, such as plant fibres and wooden artefacts, communal fish traps, boats, and house structures (Andersen 1980; Lübke 2003; Skaarup and Grøn 2004; Fischer 2007; Harff *et al*. 2007). Also, it is now clear that seismic records collected for other purposes by the oil industry can be successfully used to give detailed reconstructions of submerged landscapes, given sufficient computing power (e.g. Gaffney *et al*. 2007, 2009). The Mousterian site of Fermanville off the coast of northern France (Scuvée and Veraghue 1971; Cliquet, this volume), the Early Stone Age finds off the coast of South Africa (Werz and Flemming 2001), and the recently recovered finds of handaxes and a Neanderthal skull fragment from the North Sea (Glimmerveen *et al*. 2004; Hublin *et al*. 2009) demonstrate that material significantly earlier in date than the Last Glacial Maximum can be recovered. There are, however, some very major gaps in our current knowledge, particularly with regard to the discovery of archaeological sites on the deeper parts of the continental shelf, and an understanding of the underwater conditions in which sites are likely to be preserved and accessible to discovery. I shall return to these problems later. They represent areas of research where the chances of success are unpredictable and the costs of investigation likely to be high. If they are to be worth pursuing, something must first be said about the intellectual justification for doing so.

The intellectual case depends first and foremost on an appreciation of the history of sea-level change and its implications. The broad pattern of sea-level change in response to the glacial–interglacial cycle has been transformed by the deep-sea isotope record, as noted earlier. Modelling of relative sea level in many regions incorporating refinements of the isotope record and dated evidence of sea-level stands has produced an increasingly detailed and well-supported framework of sea-level change (Chappell and Shackleton 1986; Shackleton 1987; Lambeck and Chappell 2001; Siddall *et al*. 2003) (Fig. 25.1). The curves reproduced in Figure 25.1 are of course smoothed and subject to various potential margins of error, depending on which deep-sea records are used and on the degree of correction required to account for other factors such as temperature change that can contribute to the isotope signal. Higher resolution records in some regions and for some periods do of course also show smaller-scale fluctuations. Earth crust (isostatic) response to changing loads of ice and water masses also affects the relative position of sea level in different regions. Furthermore, the integration of geophysical modelling and dated benchmarks of sea-level position is constantly being refined (Lambeck 1996a, 1996b, 2004). A comparable pattern of amplitude and periodicity can be

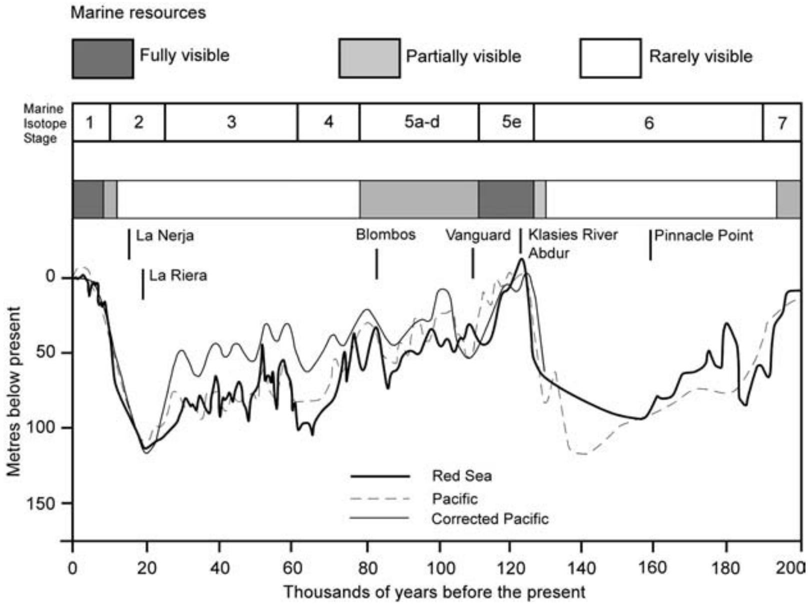


Figure 25.1: Sea-level curve over the past 200,000 years, showing likely impact on the visibility of coastlines and archaeological evidence of marine resource exploitation. Site names refer to coastal sites in Africa and the Gibraltar Peninsula with early evidence of marine resources (Sea-level data from Chappell and Shackleton, 1986; Shackleton 1987; Lambeck & Chappell 2001; Siddall et al. *2003; Waelbroek* et al. *2002)*

extended back to about 0.8 million years, with similar qualifications. In the earlier time ranges of the Pleistocene, the isotope record indicates a lower amplitude of sea-level change but with clear evidence of ongoing periodicity (Shackleton and Opdyke 1976). There remain uncertainties of measurement and variations between different records, but these cannot obscure the main point: for most of human history on this planet, eustatic sea levels have been substantially lower than the present, by about 40 m for most of the glacial cycles during the past 0.8 million years, and for shorter periods by over 100 m, with sea levels at or close to the present level accounting for no more than about 10 per cent of the total record. At the end of the Last Glacial period, sea level rose from a depth of -130 m after *c.* 19 ka cal BP to reach the modern level at *c.* 6.8 ka cal BP, so that any evidence of shoreline settlement and adaptation before that time is likely to be partially or wholly below present sea level.

Some impression of the amount of land exposed at lower sea level can be gained by looking at simple bathymetric contours. On a world scale, extensive areas of shallow shelf were exposed at the Last Glacial Maximum (Fig. 25.2). Some of these areas are at high latitudes, which would have been scarcely habitable. A conservative estimate of the additional habitable territory made available at maximum marine regression is 16 million km^2, amounting to some 10 per cent of extra land (Bailey 2004a). In Europe, the amount of new land exposed at the Last Glacial Maximum was some 40 per cent of the current European land mass (Fig. 25.3).

The first and most obvious implication of such changes, and the one most often commented on, is the increased opportunities for population dispersal or cultural contact across sea barriers between continents. Lower sea levels would have created new land connections or the narrowing of sea channels to distances that could be crossed quite easily by swimming, floating, or simple rafting without the need for advanced seafaring skills. Connections between Africa and Asia, Africa and Europe, Siberia and Alaska, and between Britain and mainland Europe, would all have benefited from these effects, and are

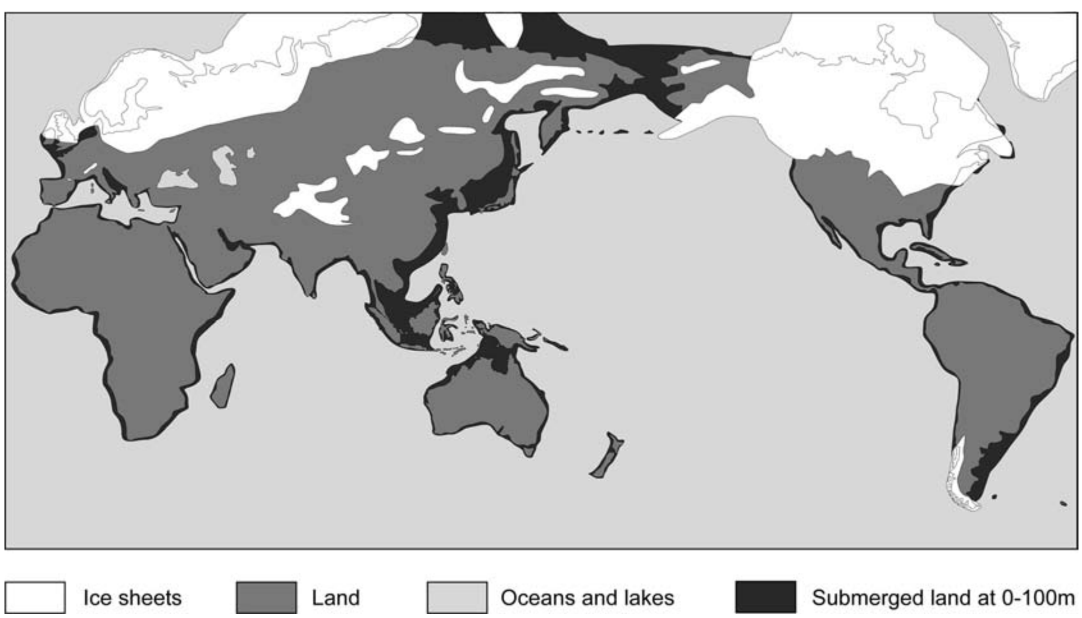


Figure 25.2: World map showing the distribution of the continental ice sheets and the extra increment of land in coastal regions at the Last Glacial Maximum (Redrawn from: Klein 1980).

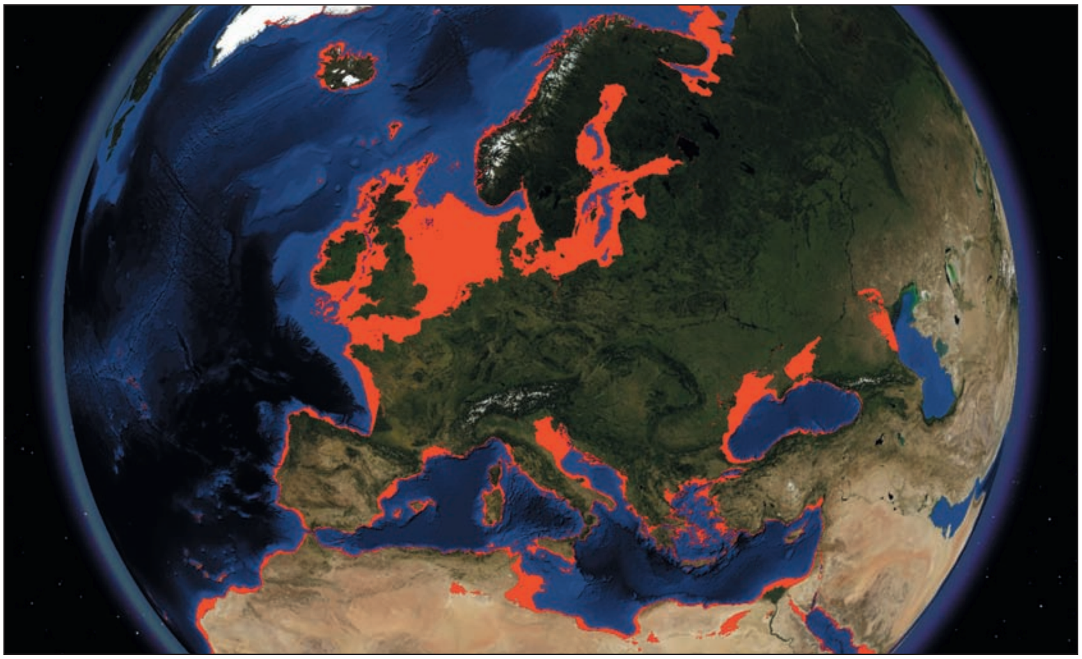


Figure 25.3: Satellite image of Europe showing, in red, the maximum extent of land exposed at the Last Glacial Maximum (Courtesy of Simon Fitch and Ben Geary, University of Birmingham, with data from USGS NED and ETOPO2)

the focus of intense current interest in relation to the history of population dispersal during the Pleistocene (Bailey *et al*. 2008; Erlandson *et al*. 2008; Petraglia and Rose 2009).

Even in Australia and New Guinea, where the persistence of sea barriers even at lowest Pleistocene sea levels would have required considerable sea journeys, the changed configuration of coastlines, islands, and archipelagos when sea-level was lower needs to be taken into account in judging the ease or likelihood of successful sea crossing and landfall. Unless earlier dated evidence awaits discovery, the timing of first entry into Sahul (Australia and New Guinea) occurred in a period, currently judged to lie between about 60–40 ka BP, when sea levels were substantially lower than present. Regardless of whether or not we think that oceanographic and ecological conditions associated with lowered sea level were more favourable to sea crossings than at periods of high sea level, the evidence required to judge the causes and circumstances of first entry is now mostly submerged. The settlements that formed the point of departure for sea travel, the settlements that were created on first landfall, the coastal environments in which these settlements occurred, the evidence for pre-existing patterns of exploitation, including any evidence of fishing or other exploitation of marine resources, must, for the most part, now lie underwater. Tectonic uplift and steep offshore topography around the edge of the subducting Pacific plate has provided some unexpected windows into marine exploitation in the time range 45–35 ka cal BP at archaeological sites like Jerimalai on East Timor (O'Connor 2007) and Matenkupkum in the Bismarck Archipelago (Gosden and Robertson 1991), but this is still a fragmentary record. As in other parts of the world, the necessary archaeological, geological, and palaeoenvironmental evidence to advance such investigations must be sought on the seabed.

In the first instance, then, the extra increment of land exposed by lowered sea level around the rim of the continental margins, or as newly emerged islands, can be viewed as a pathway linking previously unconnected land masses. But it is not simply changes in the configuration of coastlines that are significant here, or the addition of new territory. This body of new land had its own ecological and environmental characteristics that may have created more or less attractive conditions for habitation and population movement. Persuasive arguments have been advanced that the resources available on these exposed coastal lowlands would have been qualitatively different from those further inland. Coastal regions tend to provide more fertile conditions for plant and animal resources on land, with more extensive wetlands and alluvial basins, and better supplies of groundwater. For human populations, there would have been the addition of marine resources at the shore edge, representing an alternative pathway for population expansion

(Erlandson 2007), enhanced in some regions by increased fertility in response to changes in upwelling currents during the Pleistocene (Bicho and Haws 2008). Coastal regions also typically benefit from more moderate climatic conditions than their adjacent hinterlands, with warmer temperatures and better water supplies, factors that would have been of particular significance at periods of lowest sea level, when global climates were generally colder and more arid than today. Faure *et al*. (2002) have hypothesized increased flow of groundwater through springs in coastal regions at low sea-level stands, which could have further enhanced the relative attractions of low-lying coastal territory in arid climatic zones. Coastal regions also often offer convenient pathways of communication, movement and contact around the edges of continental margins, and easy access to alternative hinterland resources along river courses.

This is not to assert that coastal regions were uniformly or universally attractive regions for resource productivity and migration or contact. Coastal regions were undoubtedly quite variable in this regard as they are today, and presented a changeable and often unstable focus for human settlement because of changing sea levels and processes of erosion and sedimentation at the shore edge (Westley and Dix 2006). Nevertheless, now submerged coastal regions, especially those extending over large areas, are likely to have supported higher concentrations of settlement and higher population densities than their adjacent hinterlands, providing generally more attractive ecological conditions, and population refugia during periods of climatic deterioration.

The scale of sea-level change raises another fundamental issue about the socio-economic dynamics of early prehistory, and that is the impact that cumulative and repeated exposure of new land at the coast margin and its subsequent inundation would have had on patterns of social geography, demography, migration, economic adaptation, and cosmology. If coastal regions were primary zones of settlement, then they must have been as sensitive to the consequences of sea-level change as in the modern era. At a time when we are increasingly concerned about the potentially destructive impact over the coming decades of a sea-level rise of a few metres, it brings a new perspective to bear on the modern situation to realize that prehistoric societies across the world faced a sea-level rise of 130 m between *c*. 19 and 6.8 ka cal BP. That change, of course, was spread over many human generations and many millennia, so that the full effects would not have been experienced within a single human lifetime. Nevertheless, the rate of sea-level rise would have been sufficient to have perceptible effects within the lifetime of an individual, to say nothing of collective memories extending further back in time, particularly in regions of shallow coastal topography. The long-term cumulative effect of sea-level rise and loss of territory would have been dramatic. Similar effects, we must presume, would have accompanied progressive lowering of sea level at the beginning of the glacial cycle. At present, we can say little about these social effects because we have so little evidence to work with. And that brings us back to the fundamental question of what evidence has survived and how it is to be investigated.

The most immediate effect of sea-level change from an archaeological perspective has been to hide from view or destroy large swathes of territory likely to have been occupied by human settlement, and most of the archaeological evidence relating to the use of this submerged territory, especially the evidence for the early history of marine resource exploitation and maritime activity. Short-lived periods of high sea-level, as during the Last Interglacial, or regions of coastal uplift associated with tectonic plate motions or isostatic rebound, afford glimpses of Pleistocene coastal activity, but these conditions are too rare or too atypical to offer more than a fragmentary record, or to obviate the need for underwater exploration (Bailey and Flemming 2008).

If this general characterization of coastal regions as attractive zones for human activity is correct, then it must follow that we are missing key evidence for many of the great formative processes that shaped the development of human society before the establishment of modern sea-level at *c*. 6.8 ka cal BP, and that what we are left with is a severely truncated archaeological record that may be missing some of the most important evidence. Human dispersals and migrations, the extinction of the Neanderthals in Europe and their replacement by incoming populations of anatomically modern humans, the Pleistocene history of marine resource use and the earliest development of fishing and seafaring, the expansion of anatomically modern humans into Asia, the Americas and Australia, the post-glacial re-entry of human populations into the deglaciated regions of Northwest

Europe, the early development and dispersal of agricultural economies, and the early stages of social and economic change that ultimately gave rise to the first great civilizations – these are all developments that took place, for the most part, when sea levels were lower than the present.

The discovery of the Pre-Pottery Neolithic site of Atlit-Yam (Galili *et al.* 1993, this volume), submerged in 11 m of water offshore of the Israel coastline, is an indicator of what may be missing even from relatively recent periods when sea level was close to reaching its present level. This site demonstrated the presence of a coastal village with evidence of fishing, farming, and seafaring, revealing a hitherto unsuspected maritime component to early agricultural developments in the region. The earliest dispersal of agricultural economies westwards from their centres of origin in the Near East certainly involved island colonization and coastwise movements in the Aegean and the Mediterranean. Moreover, this would have occurred at a time when sea levels were rising toward their present level, but still somewhat lower than present, so that the low-lying island margins most likely to have harboured first landfall and the earliest agricultural settlements are now underwater (Flemming 1983; Lambeck 1996a; Runnels 2009; Ammerman 2010; Broodbank 2010). Even before this period of early agricultural dispersal, Mesolithic sites now seem to be reliably present on a number of Aegean islands (Runnels 2009). The inhabitants of Franchthi Cave were obtaining obsidian from the island of Melos from at least 12 ka cal BP, requiring a series of sea crossings of up to 20 km (Lambeck 1996a), while Cyprus was visited, if not permanently occupied, from about the same period (Ammerman 2010, this volume; Knapp 2010). The palatial settlements of Minoan Crete developed in an Aegean maritime setting with their roots in a tradition of island use and seafaring that we now know extended back before the Neolithic period. Because of sinking coastlines in many areas of the Aegean, Late Neolithic and Early Bronze Age sites are now partially submerged, as in the case of Pavlopetri (Henderson, this volume). The Ubaid settlements of Mesopotamia, which formed the earliest stage in the trajectory that gave rise to Mesopotamian civilization, were present when sea level was still rising, and must have had their roots in the vast and well-watered valley that occupied the area of what is now the Persian Gulf, until it was progressively inundated after *c.* 12 ka cal BP, and replaced by fertile marine waters and coastlines as sea level approximated its present position (Lambeck 1996b; Kennett and Kennett 2006; Carter 2010; Rose 2010). The role of coastal margins and low-lying valleys in contributing to the foundations of early agricultural and urban development and expansion has scarcely begun to be appreciated, to say nothing of the dynamic impact of loss of territory and changing ecological conditions during the process of Late Glacial and Early Holocene sea-level rise. Yet, we can at present say little beyond plausible speculation about these earliest developments, or the complex and dynamic interplay between changing environmental and climatic conditions on coastlines and hinterlands, because so little of that underwater realm has yet been explored.

Where next?

In order to identify what remains to be done, it is important first of all to appreciate the limits of current knowledge. The great majority of currently known underwater sites first came to light as the result of chance exposure or discovery of material by fishing and dredging operations, removal of protective marine sediments by storms or currents, or the activities of sport divers. Systematic archaeological investigation and underwater excavation have usually been applied in areas where finds had previously been reported, and where there was a high likelihood of collecting new material. Considerable quantities of Mesolithic artefacts were known to exist on the seafloor of the western Baltic in Danish and German inshore waters as a result of dredging and fishing activity for many decades before these received the systematic attention of archaeologists. Once some of these finds had been excavated, a body of information began to grow, which could be used to predict the likely locations and preservation conditions of other sites, so building up the momentum and the incentive for fresh discoveries (Fischer 1995b, 2007). Important sites like Bouldnor Cliff in the Solent (Momber, this volume), and Atlit-Yam, were discovered by the chance combination of exposure of archaeological material by natural erosion, sometimes quite a short-lived exposure before renewed shifting of sediments and currents re-buried or removed the archaeology, and the presence of informed archaeological divers at the time when the material was being

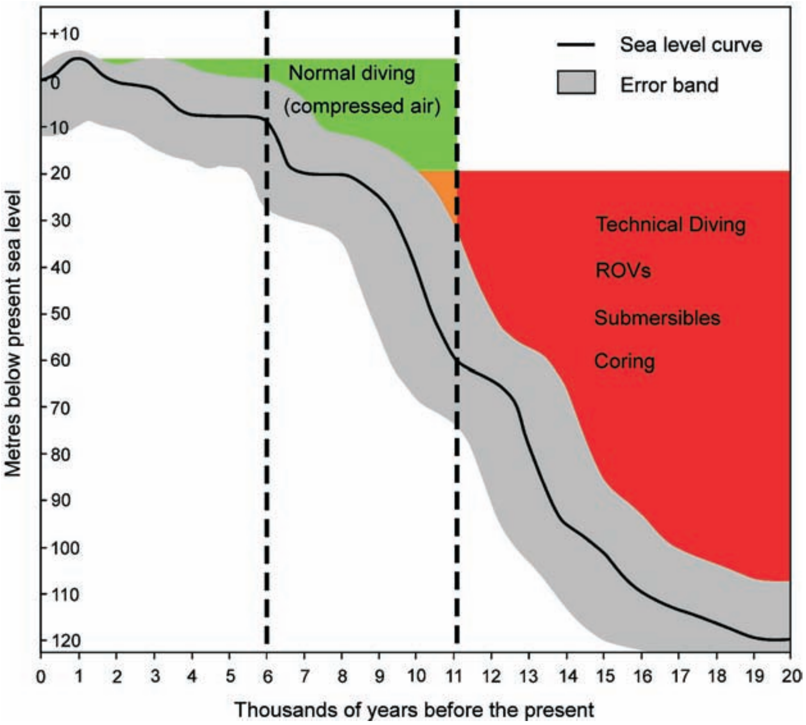


Figure 25.4: Diagram showing the relationship between the depth of the continental shelf, the age of submerged archaeological sites, and the technological gap between working in shallow water and working in deep water. Vertical dashed lines show the age range within which submerged archaeological sites accessible to divers using compressed air are likely to occur. Diving with compressed air is technically possible down to depths of 50 m, but loss of mental concentration, curtailment of time spent on the seabed, margins of error, and risks of decompression sickness all progressively increase with increased depth, and the effective limit for archaeological purposes without use of nitrox or trimix gas mixtures is likely to lie within a 20 m depth range. ROVs and other technologies can of course be used in shallow water as well as at depth (Sea-level curve from Siddall et al. *2003, showing error range of ±12 m)*

exposed. Moreover, most of this systematic archaeological excavation has taken place at shallow depths in inshore locations, where the operational logistics are relatively straightforward (Fig. 25.4).

This known material provides the basis for two types of predictive model that are important in the discovery of new material: the environmental and landscape features that are likely to have attracted repeated human activity and settlement, and hence led to the formation of archaeological deposits; and conditions in which the original archaeological deposits are likely to have been protected from destruction or dispersal by wave action and violent water currents during the process of inundation. In the Danish case, a fishing site-location model, based on modern and ethnographic information about the best shoreline locations and topographic conditions for fishing activity, has proved to be a powerful predictor of underwater sites, and deposits of peat or gyttja a good indicator of conditions with preserved archaeological material, resulting in the discovery of at least 2000 underwater find spots (Fischer 1995b, 2004; Skaarup and Grøn 2004). Similar conditions obtain in the Wismar Bay of northern Germany (Harff *et al*. 2007; Lübke *et al*., this volume). The shallow gradients and the relatively limited tidal movement in these marine basins have also undoubtedly contributed to the preservation of material.

The concentration of finds in the western Baltic is exceptional, and gives grounds for optimism that similar material may await discovery further to the east on the sinking coastlines of the southern Baltic in Poland and Lithuania. However, we do not know how typical these conditions are of other marine basins and inshore waters. Nor do we know whether the existence of isolated sites elsewhere, such as Bouldnor Cliff or Atlit-Yam, is simply the first visible indicator of a much more widespread distribution of similar well-preserved sites awaiting future discovery, or symptomatic of the few that have survived the destructive effects of inundation. The large quantities of Pleistocene terrestrial fauna that have been dredged up from the sea bottom in the southern sector of the North Sea, together with occasional finds of handaxes and a fragment of a Neanderthal skull (Glimmerveen *et al*. 2004; Hublin *et al*. 2009), suggest that a former land surface with archaeological material is accessible close to the present surface of the seabed in many areas, and would be a worthwhile target for more detailed investigation. The use of seismic records from the North Sea oil industry, though not designed for the purpose of archaeological landscape reconstruction, shows that detailed features of the palaeolandscape are still present and can be reconstructed to enable broad predictions of site locations and areas of potentially good preservation (Gaffney *et al*. 2007, 2009).

There is, however, a geographical gap in the North Sea between the areas that have produced archaeological material and the areas that have received detailed seismic survey. The former have not yet given rise to systematic acoustic surveys or close inspection of the seabed for palaeoenvironmental and archaeological material. Predictions based on landscape reconstruction in the latter areas have not yet been followed up with seabed survey or targeted coring to see

if any archaeological material has survived or is accessible to study.

This is symptomatic of a more general gap between the collection of acoustic survey data by geophysicists and geologists, and the investigation of archaeologically-defined problems, and highlights the 'technological gap' between working in shallow water and working in the deeper parts of the shelf (Fig. 25.4). In the former, targets can be identified with precision, and predicted landscape features and likely locations of archaeological sites can be ground-truthed and examined at close quarters relatively easily with high-resolution acoustic survey, coring, and divers. In the deeper areas, close inspection of the seabed will require the deployment of more costly and elaborate technologies involving sea-going ships with a variety of acoustic and coring equipment, remotely operated vehicles and cameras, and divers trained in mixed gas techniques and capable of working safely at greater depths. The exploration of mutual interests and research collaborations between archaeologists, on the one side, and scientists who already command such facilities for the purposes of geophysical and palaeoenvironmental survey, on the other, are likely to play an important role in future research. Mobilization of such a project in the North Sea will be a major undertaking and is still at the discussion stage, involving an extensive collaborative network of interested parties including academic researchers, developer-funded archaeologists, and government agencies (Peeters *et al.* 2009).

The Farasan Islands

All of the problems noted above, of integrating work on land, in shallow water and in deeper areas of the shelf, and of site survival or destruction under different oceanographic conditions, are ones that we have begun to confront in the Saudi Arabian sector of the southern Red Sea (Fig. 25.5). The impetus for this project, which began in 2004, is the growing interest in the 'southern corridor' – across the southern end of the Red Sea and the Arabian Peninsula – as a primary pathway for human dispersal out of Africa, particularly by anatomically modern humans after *c*. 150 ka BP, and the possible significance in such a dispersal of new capabilities in seafaring and the exploitation of marine resources (Stringer 2000; Walter *et al.* 2000; Oppenheimer 2003).

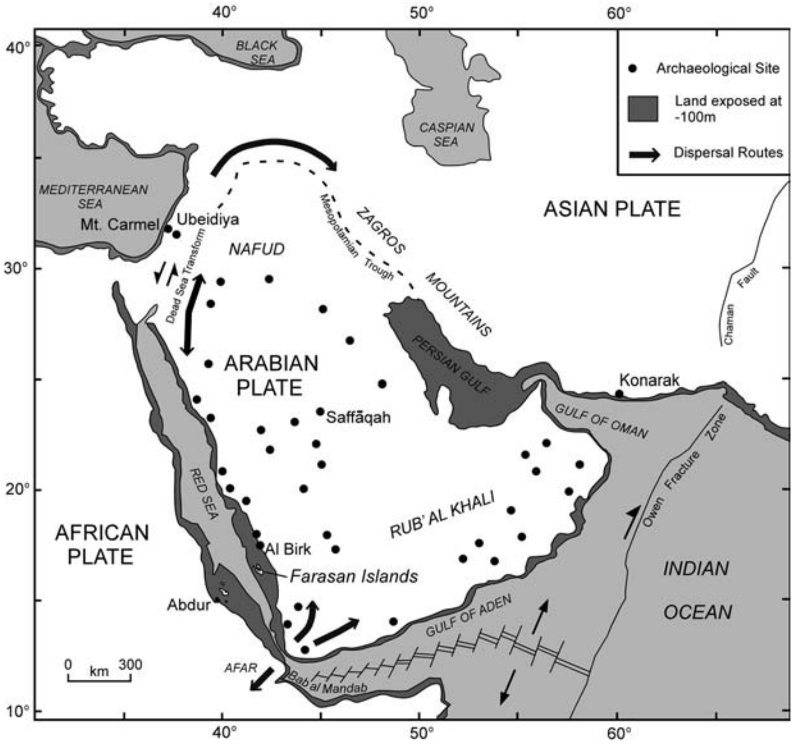


Figure 25.5: Map of the Arabian Peninsula and adjacent regions, showing the location of the Farasan Islands, the shelf regions that would have been exposed at very low sea level, major tectonic features, and a general indication of Palaeolithic sites and potential hominin dispersal routes (Drawing: G. N. Bailey and C. Vita-Finzi)

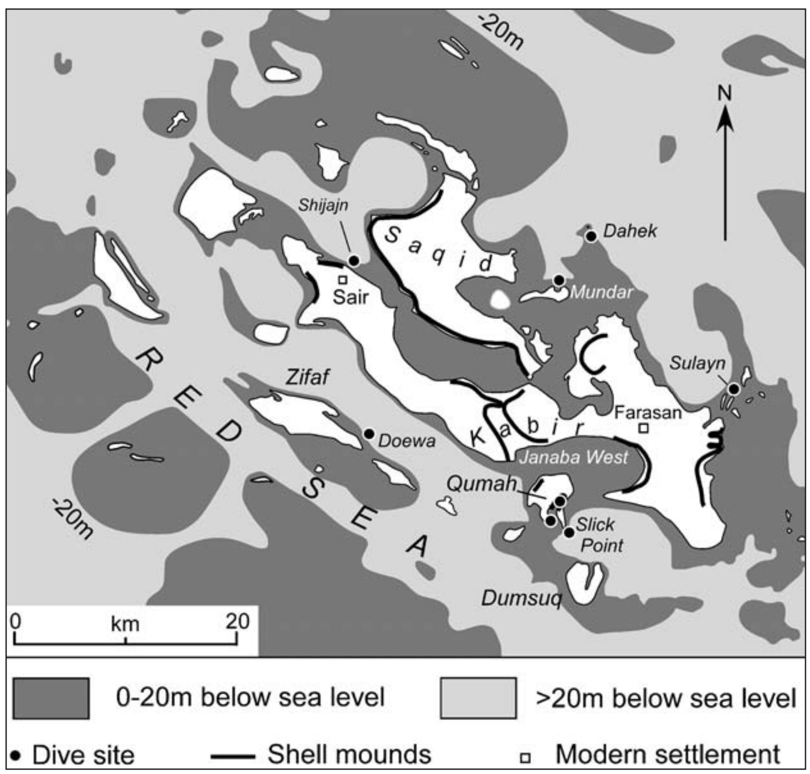


Figure 25.6: Map of the Farasan Islands showing general distribution of shell mounds on land and the location of dive areas (Drawing: G. N. Bailey and M. G. M. Williams)

Figure 25.7: Excavated shell mound at Janaba East, Farasan Islands, sitting on an undercut coral terrace. Collapsed blocks of terrace are visible in the foreground and to the right of the shell mound (Photo: Hans Sjoeholm, May 2006)

A primary objective of our project is to search for evidence of Palaeolithic occupation in the wider region and especially evidence of coastal sites. An underwater component was built into this project at the original planning stage, including a trialling of offshore methods in deep diving. The project was designed as an integrated onshore–offshore project, with survey and excavation on land proceeding hand in hand with underwater exploration, and the results of work on land acting as a guide to what to look for underwater. After a preliminary reconnaissance in 2004 to assess reported claims of Pleistocene and Holocene coastal sites, we settled on the Gizan region close to the Yemen border, and the Farasan Islands about 40 km offshore, as the focus for further fieldwork (Fig. 25.6). The Farasan Islands are composed of fossilized corals and limestone that have been progressively pushed up by the action of salt tectonics since at least the Miocene. The islands would also have been part of the mainland when sea levels were lower than about 40 m, so that access to them during the Pleistocene would not have depended on sea travel. Occasional finds of Middle Stone Age or earlier artefacts confirm that the islands were visited during the Pleistocene (Alsharekh *et al*., in press). As sea levels dropped during glacial cycles, an extensive coastal landscape with a complex topography of deep depressions, alluvial valleys, archipelagos and convoluted shorelines and embayments would have been exposed, reaching a maximum width of some 100 km on both sides of the southern Red Sea. This would have created a potentially important addition of territory. In addition, the sea passage through the Hanish Islands and the Bab al Mandab would have been reduced to a long and narrow channel or series of channels posing little barrier to human transit between Africa and the Arabian Peninsula (Bailey 2009).

Surveys and excavations on land were conducted in 2006, 2008 and 2009, combined with deep offshore work in 2006, and diving work in shallower water using conventional SCUBA techniques in 2008 and 2009. The results of this work are reported in detail elsewhere (Bailey *et al*. 2007a, 2007b, 2008, in press; Bailey 2009, 2010; Alsharekh *et al*., in press). Here, I summarize the strategic and logistical issues.

The key to the initial strategy lies in the immensely rich concentration of shell mounds that we discovered during the course of land survey on the Farasan Islands in 2006 and the location of many of them on shorelines consisting of a fossilized coral terrace that has been undercut by the erosive effect of seawater (Fig. 25.7). The number of shell mounds, more than 1000, and the size of the largest, exceeding 4 m in height, is exceptional by any standards. It reflects in part the high marine productivity of the shallow tidal bays around the islands and a rich and extensive molluscan fauna, and probably, in part, the lack of modern development on the islands until very recently and hence the preservation of the shell mounds from destruction and removal by industrial activity. Such shell middens are not unique to the islands. Similar sites have been reported along the coastlines of the Arabian mainland, but the concentration and conditions of preservation of the Farasan sites are unusual.

As might be expected from other parts of the world, the earliest radiocarbon dates for the shell mounds are in the 6th millennium cal BP, coinciding fairly closely with the establishment

Figure 25.8: The MV Midyan in Farasan waters (Photo: Hans Sjoeholm, May 2006)

of modern sea level. If the appearance of the shell mounds from this date onwards is solely the result of increased visibility after cessation of sea level rise, then it follows that earlier shell mounds should have formed when sea levels were lower than the present. We further hypothesized that, if the submerged shorelines of earlier periods were associated with stillstands and the creation of undercut notches like those visible on much of the present-day shoreline, it should be possible to locate these earlier shorelines underwater, and that this in turn would provide an identifiable target in the search for submerged shell mounds or other archaeological material.

Initial underwater work involved single beam acoustic survey and diver inspection at a variety of depths with a team of divers trained in the use of mixed gas diving (nitrox and trimix), and capable of working at depths down to about 90 m. This work required the use of an offshore platform large enough to house a diving team of six personnel, a decompression chamber, diving equipment, a supply of gas cylinders, and two small boats for accessing dive sites. The cost of chartering a suitable vessel from a base in the Gulf or northern Egypt proved prohibitive given our budget at that time, but in the event a suitable vessel, the 2000 tonne MV Midyan (Fig. 25.8), based at the port of Jeddah in the Red Sea, was made available free of charge by Saudi ARAMCO. Without that offer, offshore work, especially in deeper water, would have been impossible. A series of mixed gas dives were successfully completed, and deeply submerged palaeoshorelines with characteristic notched undercuts were found at depths ranging from 12 m to 60 m. These were mapped over short distances and sampled for geological material by the diving team. Small deposits of shells that might represent cultural remains were identified but lack of time prevented more detailed investigation.

The offshore work was successful in establishing the parameters and logistics of working in deep water in this region. It demonstrated the feasibility of diving work at depth, showed the presence of easily identifiable submerged palaeoshorelines, and identified constraints on future diving work. In some cases the submerged shorelines were covered by marine sand and were identifiable only as a break in slope. In other cases the shorelines were fully exposed with an undercut notch extending laterally over considerable distances. This variation highlights the variable impact of marine currents and patterns of marine sedimentation on the visibility of features in the original terrestrial landscape. Some submerged shorelines were also clearly tilted as a result of tectonic movements, and similar tilting is visible on the present-day shoreline.

The original plan in 2008 and 2009 was to follow up the offshore work with more extensive mapping of submerged shorelines and other topographic features using the full range of acoustic techniques (multibeam, sub-bottom profiling, and side-scan), alongside continued survey and excavation on land. However, the difficulties of sourcing suitable boats and equipment available for use in the inshore regions of the Farasan Islands led to a change of strategy, and the offshore work switched to diving in shallow water. The objectives of this work were to target submerged shorelines at shallow depth in areas adjacent to modern shorelines with concentrations of Middle Holocene shell mounds, to concentrate in particular on submarine areas with limited accumulation of marine sediments, or areas where marine channels might have cut through previously accumulated sediments, thus exposing earlier terrestrial land surfaces, to search for archaeological sites, and more generally to develop a fuller understanding of the taphonomic processes affecting submerged landscapes and archaeological material.

We have identified a number of palaeoshorelines in the 6–20 m depth range, some with deeply undercut overhangs that would have provided excellent shelter for temporary human encampments, and we have conducted preliminary underwater excavations in selected locations under rock overhangs. Artefacts or sediments with clear evidence of prehistoric activity have so far proved elusive. This may reflect the limited sources of distinctive material suitable for making stone artefacts in the wider region, such as basaltic lava or fine-grained siliceous rocks. Even in surveys on land and excavations of the shell mounds, stone artefacts are rare, comprising items made on non-local volcanic stone, and local materials consisting of fine-grained limestone and *Tridacna* shell. The latter is a large, thick-walled shell, which can be flaked, and produces material which, on first appearance, looks rather like a coarse-grained chert.

Relatively small underwater shell deposits or shell scatters of limited extent have been identified but these pose the difficulty of distinguishing

between anthropogenic and natural shell deposits. This is a problem even with shell deposits on dry land, and there are many cases where shell accumulations believed to be middens have turned out to be natural, or where deposits claimed to be natural have been demonstrated to be cultural (Bailey *et al*. 1994; Sullivan *et al*., in press). These problems are, if anything, greater for submerged material, because even cultural shell deposits are likely to have undergone some erosion by water action, which is often taken to be the distinguishing feature of natural shell deposits. Moreover, the seabed is littered with extensive scatters of shells representing natural death assemblages. This is a major taphonomic challenge for underwater shell deposits, and work is ongoing to identify robust criteria for classifying the Farasan underwater material.

What we have not so far found underwater are any substantial shell deposits that might be described as discrete shell mounds like those visible on land, and this may be for at least four reasons. First it is possible that even substantial shell mounds on shorelines well protected from the full force of wave action and water currents during submergence undergo degradation and dispersal of material by water action, so that what remains is quite different from the original deposits, perhaps representing a diffuse scatter of shells that may be very difficult to distinguish from the background noise of natural death assemblages of shells on the seabed.

A second possibility is that we have not yet looked in the right underwater areas. Even on the modern shoreline, the shell mounds are quite patchy in their distribution, with extensive areas of coastline that lack shell mounds or have only ephemeral evidence of human activity such as small surface scatters of shells and occasional hearths. Also, the area that can be covered in a given time by divers is much more limited than on land, where extensive areas can be covered on foot and by vehicle, aided by satellite images on which the larger shell mounds are clearly visible (Fig. 25.9). It is possible that high-resolution acoustic survey techniques may in due course be able to identify underwater shell mounds, but until we have some understanding of how shell mounds are degraded by submergence and what the acoustic traces of known deposits look like, progress on this front is likely to be slow.

A third possibility is that the ecological conditions necessary for the establishment of large beds of shells were not present on the now-submerged shorelines, or only rarely so. It is a notable fact that the largest known concentrations of shell mounds are associated with large shallow bays, which in many cases have now become dry sand-filled basins as a result of ongoing accumulation of marine and windblown sands or tectonic uplift, or both processes working together (Fig. 25.9). Shallow bays of this type are highly dynamic in geomorphological and ecological terms, representing relatively short-lived windows of opportunity for the establishment of large shell beds and intensive shell-gathering, even with a stable shoreline and a stable sea level. During a period when relative sea level is undergoing a sustained rise, or a sustained fall, these subtle shoreline changes affecting shell habitat are likely to be even more dynamic, and it is possible that beds of living shells were never established in sufficient numbers in one place to allow the accumulation of substantial midden deposits during the period of sea-level oscillations characteristic of the Pleistocene record and particularly the period of rapid sea-level rise after the Last Glacial Maximum. Fischer (1995b: 382) has made a similar point about the low visibility of shell middens and the low density of artefact concentrations likely during a period of rapid marine transgression in Early Holocene Denmark because of a constantly moving shoreline. An added factor in the Red Sea context is that when sea levels were very low, reduced inflow of seawater from the Indian Ocean combined with high evaporation rates created very high salinities that could have inhibited marine productivity and substantially reduced the diversity and abundance

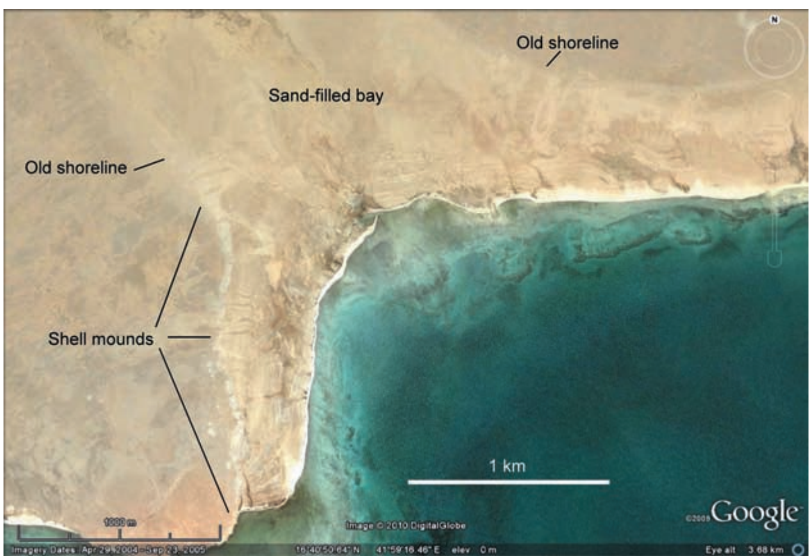


Figure 25.9: Google Earth image of Janaba West showing shell mounds visible from the air on the western shoreline of a former, large, marine inlet, which has now become filled with sand. Numerous shell mounds are also distributed along the former shoreline on the opposite side of the sand-filled bay, but are not so easily visible from the air

of molluscan faunas. However, this probably applies with more force to the central and northern Red Sea than the south, and even there only to periods of maximum marine regression.

Finally, we have to consider the possibility that the shell mounds represent an intensification of shell gathering activity associated with changing patterns of human demography, social organization, and settlement unknown at any previous period in prehistory. One factor that may be relevant in the southern Arabian context is that a major climatic change toward more widespread aridity occurred in the Middle Holocene after *c.* 6 ka cal BP (Parker 2009; Carter 2010). During the Early Holocene, the Indian monsoon extended into the Arabian hinterland bringing wetter conditions which saw the spread of settlements into the interior. When climate became drier these settlements were abandoned, and one might argue that this regional shift in settlement and population demography forced populations to intensify the exploitation of alternative resources such as shellfish and other marine resources available at the coast edge. This is a regional variant of the more widespread hypothesis of post-glacial intensification noted earlier, but it remains difficult to test because the date of this postulated change also coincides quite closely with the establishment of modern sea levels and therefore with an increase in the visibility of coastal archaeological sites. It will, therefore, remain very difficult to corroborate without elimination of the alternatives. This in its turn underlines the need for continued investigation of the submerged landscape.

Gibraltar

In 2005, while the logistics of the proposed Red Sea underwater work were being investigated, and further fieldwork planning was put temporarily on hold because of the geopolitical situation, a trial survey and preliminary excavation was undertaken of submerged caves offshore of Gibraltar. These caves had been known about since the 1960s (Flemming 1972), and were selected as a suitable and easily accessible target for the Red Sea diving team to obtain some experience in mixed gas underwater work within the context of ongoing excavation at Gorham's Cave and Vanguard Cave on Governors's Beach at the southern end of the Gibraltar Peninsula (Stringer *et al.* 2000; Finlayson *et al.* 2006; Stringer *et al.* 2008) (Fig. 25.10).

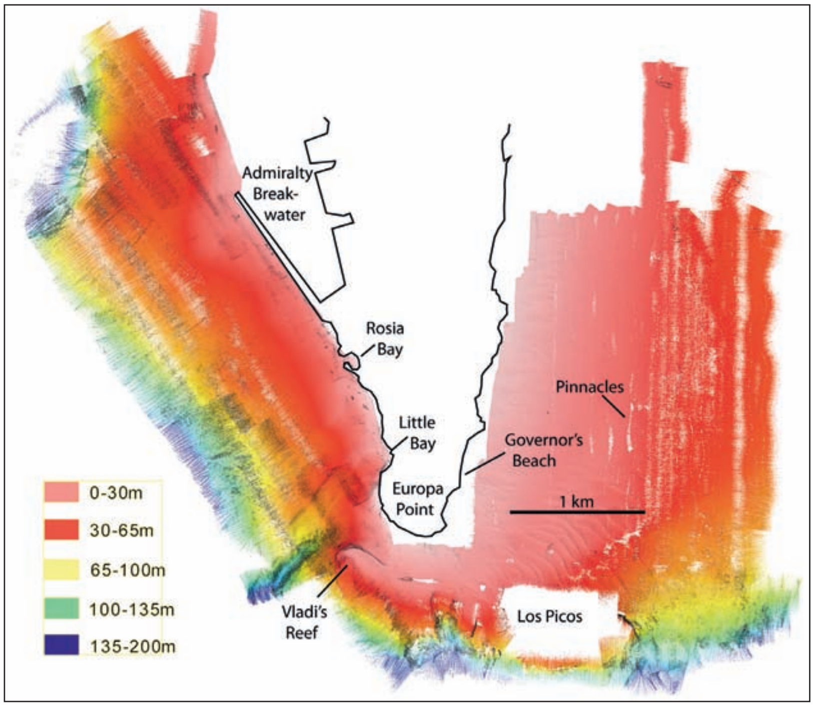


Figure 25.10: General map showing Gibraltar, the general bathymetry of the offshore area around the end of the Peninsula, Vladi's Reef, and other features and locations mentioned in the text (Depth scale in metres; Data supplied by IX Survey Ltd)

Gibraltar is of particular interest for investigating submerged landscapes because the shelf is relatively narrow, not more than about 4–5 km wide at maximum marine regression on the eastern side of the Peninsula, and somewhat less on the western side, thus providing a relatively compact and well circumscribed area for investigation. The region is also of interest as a potential transit for hominin dispersal from Africa into Europe. The width of the strait between Gibraltar and North Africa is about 11 km and, although this would not have been much affected by a drop in sea level, the distance is short enough to raise the possibility of sea

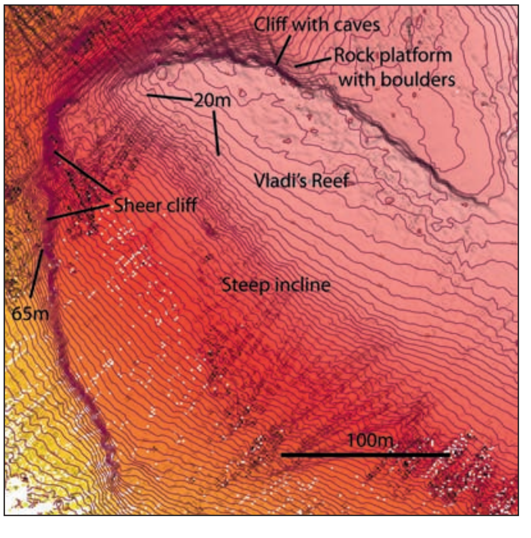
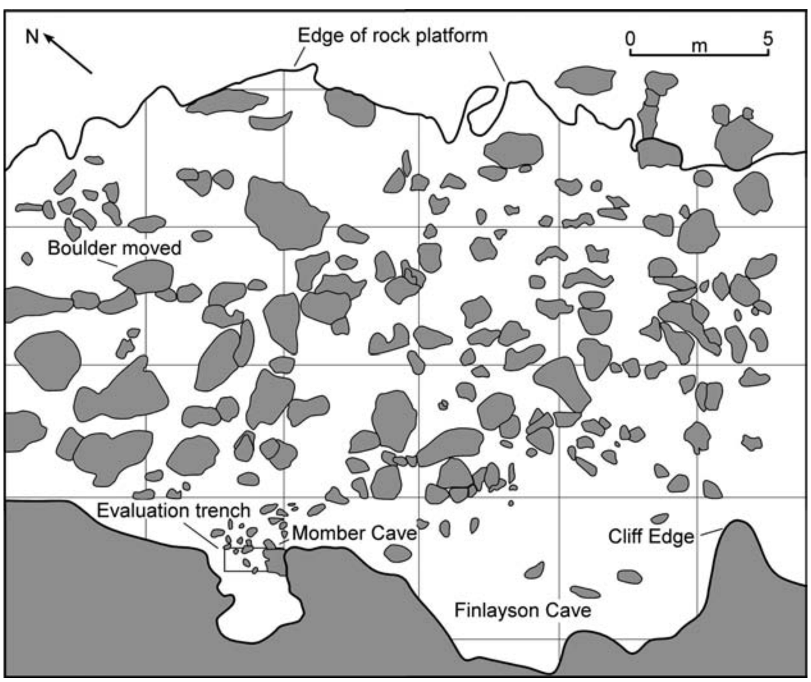


Figure 25.11: High-resolution bathymetry of Vladi's Reef (Data supplied by IX Survey Ltd, with annotations by G. Momber)

crossings by swimming or rafting (Bailey *et al.* 2008). The underwater caves are located on a submerged reef known as Vladi's Reef (Figs 25.10 and 25.11). This is a submerged formation of breccia extending for about 2 km on an east–west axis, with its crest at a depth of about 12 m below sea level, and only about 200 m offshore. On the north face of the ridge, there is a 6 m high cliff with a series of cave openings and a boulder strewn plateau at its base. On the south and west sides there are taller cliffs and at least one cave opening at a depth of 65 m.

In the case of the caves facing toward the mainland, any terrestrial deposits accumulated in the cave mouths are likely to be better protected from the erosional effects of sea-level rise than would be the case if the caves had been facing out to sea and exposed to the full force of wave action. In the event, after a trial exploration of Vladi's Reef, mapping of the boulder field, and preliminary excavation of Momber Cave in 2005 (Fig. 25.12), the focus of our research shifted back to the Red Sea. A further spell of combined underwater excavation and acoustic survey including multibeam, sub-bottom profiling, and side-scan was undertaken in Gibraltar in 2008 (IX Survey 2008). This latter work was dedicated to more extensive mapping and characterization of the submerged landscape around the full perimeter of the Gibraltar Peninsula, to diving inspection of potentially promising locations around Vladi's Reef, Los Picos and the rocky pinnacles on the eastern side of the peninsula, to further excavation of Momber Cave and sediments beneath protective boulders in front of the cave opening, and to collection of rock samples to clarify the geological origin of the reef.

Figure 12: Cave openings and boulder field on the north side of Vladi's Reef (Drawing: G. Momber and G. N. Bailey)



During the course of this work, we faced a number of difficulties that are symptomatic of the constraints on underwater work. Excavation by divers working at a depth of *c*. 20 m is a slow process, which is necessarily subject to frequent interruptions to comply with health and safety regulations, the rotation of diving teams, the lifting of excavated materials to the surface, and the cessation of work because of changes in tidal currents or spells of rougher weather, both of which were a persistent and continuing source of interruption. A fixed grid was positioned on the seabed to facilitate the survey of the caves and their immediate environs (Fig. 25.12), and excavation within the mouth of Momber Cave has progressed over an area of 2 m^2, and down to a depth of 0.6 m through marine silts to reach a layer of rounded boulders. It is possible that deeper deposits lie beneath this boulder bed, or beneath the extensive rockfalls in front of the cave mouth, which represent earlier episodes of roof collapse, and which may well have served to protect underlying terrestrial deposits accumulated in the pre-inundation landscape. However, renewed work on a larger scale with equipment capable of shifting or removing large boulders will be required to test this possibility.

The acoustic survey has provided an overview of the submerged topography but was compromised by a number of factors. A recent shipwreck near Los Picos restricted access to one area, though the salvage company undertook its own bathymetric survey and subsequently made the data available to us. Also, the large number of cargo vessels and oil tankers at anchor meant that transect lines had to be adjusted to avoid them, with some loss of coverage. Bad weather conditions were also a persistent problem, leading to the cancellation or premature cessation of work on some days, and to the repatriation of the survey team to the UK for other work and their return at a later date, with additional mobilization costs. Future work is planned including renewed excavation at Vladi's Reef, higher-resolution acoustic survey of selected areas identified in the existing survey, and coring and

diver inspection of other target areas with the potential for recovery of terrestrial sediments and archaeological material.

Discussion

There are three issues that arise from this summary of recent research. The first is that underwater work is slow and painstaking, especially where diving work at depth is involved. Health and safety regulations require diving work to be planned accordingly, with a large enough team of trained personnel to ensure surface supervision of diving activity, medical support, alternating diving teams operating in pairs, and regular rest periods. Diving equipment needs to be properly maintained, boats of suitable size for providing access to diving areas and facilities for refilling gas cylinders need to be available, and rapid access to a recompression chamber and hospital facilities in case of accidents is essential. Divers should ideally have training in archaeology as well as in diving techniques. In contrast to work on land, the area that can be surveyed by divers at any one time is much more restricted. Divers need to maintain direct communication with a surface boat, and cannot undertake repeated ascents and descents because of the threat of decompression sickness. They can only move a few hundred metres laterally during a dive, and this manoeuvre is restricted to depths of the order of 10–30 m. At greater depth they have to be attached to a work station or surface supply. All of this imposes limits on the areas that can be covered and sampled, and this in its turn restricts the number of specific locations that can be identified as targets for more detailed investigation.

Ideally, diving work should be preceded and accompanied by acoustic survey and by remotely operated cameras and remotely operated or autonomous underwater vehicles and submersibles that can cover larger areas and identify potential target areas for close inspection by divers or for drilling and coring work. These techniques can provide a wide range of information but are not a sufficient substitute for diving. Divers can inspect features at close range within their surrounding context, take measurements, make drawings, and take video and still photographs with greater flexibility than remotely operated cameras. They can also collect geological and other samples, and ultimately conduct excavations.

Offshore work also requires suitable boats. For technologically demanding work, especially for mixed gas diving, drilling and use of underwater vehicles, a large platform is essential, with sufficient deck space and on-board accommodation, typically a ship of 50–60 m length. However, boats of this size have limited manoeuvrability in shallower water where survey may be required, so that smaller boats are also essential for comprehensive survey. Weather conditions can cause delays, especially for smaller boats. In the worst of the weather during the Gibraltar operation the harbour was closed to all shipping. A large ship can ride out rough seas, but diving operations may have to be aborted in such conditions, and acoustic survey may produce poorer resolution or have to be halted. In the Farasans, the coastguard authorities regularly closed down all small-boat activity when winds exceeded a certain strength, sometimes on a daily basis. These constraints are well understood by scientific divers and specialists in offshore and underwater activities, but not necessarily well known to archaeologists who are called upon to plan or participate in such operations, or comment on their results. My own experience suggests that one should assume as a minimum that, for every three days of planned offshore operations, two of these days are likely to be interrupted or written off completely because of various contingencies and operational factors, with obvious cost implications for budget planning and the scope of work undertaken.

The second issue is that of cost. Underwater work is necessarily expensive, especially if ship time is involved, together with the use of specialist skills and equipment. A large ship used in a complex operation may cost anywhere in the range of €250,000 to €500,000 for a 10-day operation, depending on the distance from the home port of the ship to the field location. The additional costs of mounting a diving or drilling operation can easily add another €100,000 to the bill. For more extensive survey, or more detailed work on a subsequent occasion, these figures should obviously be multiplied accordingly. The work we carried out in the Farasan Islands could not even have been contemplated, let alone completed, without very considerable assistance from Saudi Arabian commercial and governmental organizations. Saudi ARAMCO were willing to put at our disposal free of charge a fully crewed ship that would otherwise have been stationed on standby duties. The shallow

diving work that we undertook in subsequent years would not have been possible without the provision of boats, gas cylinders, air compressors, and other facilities by the Farasan coastguard authorities. There are no shortcuts to underwater work especially where diving is concerned because of safety considerations. But there are opportunities, as we discovered, for enlisting the help of government agencies and large industrial organizations engaged in offshore work, who often have the necessary facilities and equipment and are willing to make them available for little or no charge as a gesture of goodwill and a contribution to public relations and wider cultural engagement. Acoustic data collected in the course of commercial activity can also sometimes be made available for archaeological purposes. Collaboration with other scientists engaged in offshore or underwater work, for example in relation to ecological, geological, or palaeoenvironmental survey, may offer additional opportunities for cost-savings through sharing of facilities or data.

The third issue is that we are still at a very early, exploratory stage in understanding what to look for when conducting surveys underwater in terms of our understanding of the taphonomic transformation of landscape features and archaeological sites by marine action, and what sorts of locations to target to maximize discovery of surviving material in different environmental conditions. There are still a great many unknowns here, and still little more than the sketchiest framework of general principles. Criteria that work in one set of underwater environments cannot necessarily be transferred without modification to another. Shallow gradients and an abundant sediment supply may minimize the destructive effect of wave action during inundation and promote rapid burial and protection. But these conditions are also likely to produce continued accumulation of sediments with limited opportunities for the discovery of deeply buried archaeological or palaeoenvironmental material. Deep locations near the edge of a shallow continental shelf pose greater technological challenges of access, but may have less overburden of later sediment because of their greater distance from mainland sources of eroded sediment washed into the sea. Complex offshore topographies offer many opportunities for the protection and survival of data because of convoluted shorelines and complex regimes of alternating sedimentation and erosion. Knowledge of taphonomic conditions and likely conditions of site preservation in different types of marine setting is gradually accumulating, particularly in areas such as the North Sea (e.g. Ward and Larcombe 2008; Westley *et al.*, in press). Such investigations could usefully be expanded to other types of marine setting with different geological and oceanographic regimes. Regardless of whether such studies lead immediately to the discovery of archaeological sites, they will help to expand the comparative base of taphonomic knowledge for the discipline as a whole.

Our own surveys have not yet produced unequivocal evidence of submerged archaeology. However, they have enabled us to build up a platform of knowledge and understanding about the taphonomy of the submerged landscapes in which we are operating and the most appropriate procedures and technologies for their further investigation, and these provide an essential foundation for future research. One type of investigation that would be extremely useful in the Farasan Islands, or indeed elsewhere, would be to find shell mounds that have been partially submerged or otherwise affected by marine erosion. Most of the larger shell mounds that we have so far recorded on land are either situated on top of undercut fossilized coral terraces, and are above the reach of modern wave action. Or else they are situated around the inner edge of shallow bays that have become filled with sand and are therefore now well inland of the modern shoreline. Nevertheless, given the effect of the local tectonics in producing localized warping of shorelines with modest uplift in some places and downtilting in others, there is a chance that we may yet find examples of partially submerged archaeological deposits which can provide insight into the effects of marine inundation.

One potentially destructive factor for shell mounds located over undercut notches during a prolonged stillstand, such as the current period of high sea level, is that continued marine erosion of the notch may eventually lead to partial collapse of the overhang and any deposits sitting on top of it. One of the shell mounds where we undertook detailed excavation is in such a position, and blocks of collapsed coral sitting on the strand line immediately below the site attest to partial collapse of the overhang (Fig. 25.7). The seaward edge of the shell mound extends to the very edge of the overhang, and we suspect that some of the midden deposit has already been lost because

of such collapse. The notch already penetrates some metres below the surviving mound, and continued erosion may lead to further collapse and loss of archaeological material. We have not yet investigated whether any traces survive on the seabed immediately below the site that could be identified as collapsed midden deposits, but this and other high-resolution studies of midden taphonomy are an obvious target for future investigation.

Conclusion

Many new archaeological finds from submerged landscapes are being discovered, new technologies of underwater investigation are becoming more widely available, and there is considerable optimism about the likelihood of future discoveries. At the same time, CSA is still very dependent on chance finds, and on developing systematic programmes of research that work from known material on the seabed. We have not yet reached the stage where we can imagine planning with confidence a systematic underwater survey for archaeological sites on the submerged landscapes of the continental shelf as a self-contained programme of research in *terra incognita*. The costs involved in such an undertaking and the risks that it might fail to discover any archaeological material still seem too high. At the same time there are clearly ways of moving forward. A great deal can be learned in well-targeted surveys about the topography, environments and preservation conditions of the submerged landscape, even if no archaeological sites are discovered. Moreover, onshore and offshore work, and work in shallower water and deeper water, are all part of a continuum. Each can bring different sorts of information to bear on the interpretation of the submerged landscape and the deep history of coastal archaeology and pose questions that can help to focus further investigations. Also, projects that combine onshore and offshore work provide tactical advantages as well as intellectual ones; by combining predictable targets on land or in shallow water where the chances of success are high with more challenging and speculative targets in deeper water, they offer the best chances of maximizing the return on research funding and investment of time and skills. The greatest chances of success are likely to come in conditions where the full range of available technologies can be integrated and the work implemented within a collaborative framework that can draw on the widest range of funding and resources.

Planning on that scale is currently focused in Europe where there are three research networks currently working toward these goals. The first is the 'North Sea Prehistory Research and Management Framework' (NSPRMF) (Peeters *et al.* 2009). The second is the IGCP 521/INQUA 501-sponsored project on the Black Sea: 'Caspian–Black Sea–Mediterranean corridor during the last 30 ky: Sea-level Change and Human Adaptive Strategies' (Yanko-Hombach *et al.* 2007; http://www.avalon-institute.org/IGCP/). Finally, and most recently, there is the EU-funded COST (European Cooperation in Science and Technology) Action TD0902 SPLASHCOS: 'Submerged Prehistoric Archaeology and Landscapes of the Continental Shelf' (http://php.york.ac.uk/projects/splashcos/), which is funded to coordinate research and management of archaeological and palaeoenvironmental archives on the sea floor across the whole range of European coastal states and their neighbours in the Black Sea and the Mediterranean. The SPLASHCOS programme funds meetings, workshops, and training programmes, and its aims are to develop links with government, industry, and a wider public, and to form collaborative partnerships that can lead to applications for large-scale funding of new CSA projects.

Large-scale collaborative projects are not unknown in archaeology, where major excavations often require large teams of specialists from different disciplines. Successful research in CSA is likely to demand a different order of collaboration, with teams that are capable of cooperating across many international and disciplinary boundaries and the involvement of commercial and government organizations. There will continue to be uncertainties and risks of failure. What is certain, however, is that we will not reduce these risks by doing nothing and staying at home in the belief that we will fail. Nor will we learn anything new unless we set out to look for new evidence on the submerged continental shelf with well devised strategies and techniques. Above all such research will require a new generation of specialists who are trained simultaneously in the disciplines of prehistoric archaeology and underwater survey. As all these ingredients begin to come together, so it may be possible to look forward to the further development of CSA as a recognized field of endeavour

in its own right, and as an essential contribution to the deeper investigation and understanding of human prehistory, with the funding and facilities to match.

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Epilogue

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Terra incognita

For much of prehistory sea levels were much lower than at present, exposing vast tracts of the continental shelves, which then became available for human settlement. These now submerged landscapes are the least represented regions within prehistoric archaeology, and they offer great promise for research and present various challenges in the technical means needed for their exploration and understanding.

Global sea level rose *c*. 120 m as the ice sheets of the Last Glaciation melted (cf. Fairbanks 1989; Lisiecki and Raymo 2005; Preface: Fig. 0.1). For decades scattered finds of marine shells, bones of fish and sea mammals, and stable isotope analysis of human remains from sites on land have indicated the existence and importance of human activity in now submerged coastal zones all over the world and far back in time (e.g. Cleyet-Merle and Madelaine 1995; Fischer 1996; Stiner 1999; Henshilwood *et al*. 2001; Pettitt *et al*. 2003; Balme and Morse 2006). This volume has demonstrated, with examples from three continents, that significant evidence of prehistoric settlement did in fact survive the transgression and that submerged landscapes are accessible for archaeological research. The quality and significance of some of this material is unparalleled in world archaeology.

The now submerged coastal lowlands must have been some of the world's most attractive environments for prehistoric foragers, fishers, and farmers. They are likely to have had some of the highest population densities, and to have been strategically important in the spread of people and ideas between regions and, ultimately, around the globe (Bailey; Fischer; Flemming; Galili and Rosen; Westley *et al*.; cf. Masters and Flemming 1983; Johnson and Stright 1992; Fischer 1995; Flemming 2004).

Submerged archaeological sites that are preserved in oxygen-deprived conditions, whether salt water or freshwater environments, are of special importance owing to their potential for survival of fragile, yet informative organic materials (Fig. 26.1). We have presented examples from marine environments (e.g. Andersen; Benjamin *et al*.; Filipova *et al*.; Galili and Rosen; Momber; Nymoen and Skar; Yanko-Hombach *et al*.) and included three chapters illustrating the range of settlement, subsistence, and technological evidence recovered through underwater archaeological work in lakes and rivers (Gaspari *et al*.; Leineweber *et al*.; Mazurkevich and Dolbunova).

Uneven distribution of submarine finds

The western Baltic appears exceptional because of its many archaeological finds from the seabed (Andersen; Fischer; Lübke *et al*.; Uldum). Some of this richness is perhaps, in part, the result of conditions specific to the marine sediments of the region. Generally, sites are better protected against erosion as the shallow water archipelagos and fjords provide relatively calm environments compared to areas exposed directly to the waves of the world's major oceans. It may be that the wealth of finds from the western Baltic is also the result of its relatively hospitable environment. Archaeologists can work there without the complications of deep water, large waves, strong tidal currents, or dangerous animals. In addition, the stone artefacts that are the most abundant

Figure 26.1: Occupation refuse deposited in shallow water off the Mesolithic coastal site of Tudse Hage, Denmark. Such permanently waterlogged sediments rich in detritus and deprived of oxygen often have excellent preservation of faunal and floral material (Photos: Jørgen Dencker, The Viking Ship Museum, Roskilde)

evidence for early post-glacial settlement in the western Baltic are frequently relatively large in size, and thus can be fairly easily observed when compared to many other coastal regions around the world. Furthermore, the conditions for the preservation of prehistoric wood are perhaps better than in other areas with higher salinity and water temperature where biological destruction of organic materials is more rapid.

The existence of a well-preserved site off the coast of southern England is, however, testimony to the survival of Holocene landscapes rich in wood (some of which may have been worked by humans) – and this in spite of its location in relatively saline water that experiences strong tidal currents (Momber). This point is reinforced by reports of submerged peat and tree stumps rooted in the seafloor beneath the saline waters of the central and southern North Sea and elsewhere around the coasts of England (also compare Özdoğan's description of tree stumps at a coastal wetland site near Istanbul, and the evidence presented by Benjamin *et al*. and Filipova *et al*. for vertical piles of prehistoric age at submerged sites in the Adriatic and Black Sea, respectively). In addition, the North Sea has produced scattered finds of Upper Palaeolithic and Mesolithic artefacts of bone and antler (Peeters; Tizzard *et al*.) as well as numerous unworked animal bones of Pleistocene and Early Holocene age, and even a fragment of a Neanderthal skull (Peeters). Rich assemblages of plant food remains, wooden implements and animal bones, and graves with well-preserved human skeletons have been recovered from underwater sites off the coast of Israel (Galili and Rosen). Moreover, finds of worked bone, antler, and/or stone are reported from such different underwater environments as the Gulf of Mexico (Faught and Gusick), Norwegian fjords (Nymoen and Skar), Atlantic France (Cliquet *et al*.), the Adriatic (Benjamin *et al*.), the Black Sea (Filipova *et al*.; Özdoğan; Yanko-Hombach *et al*.), and the coastal waters of Cyprus (Ammerman *et al*.).

This volume has presented an array of archaeological features that have survived inundation, including water wells, dwellings, and human burials (e.g. Cliquet *et al*.; Uldum). Some of the more breathtaking finds come from water depths of up to 12 m off the coast of Israel (Galili and Rosen). One might expect that very few *in situ* traces of human activity would have survived inundation and subsequent wave action along the relatively exposed eastern Mediterranean coast. However, submarine sandstone ridges, roughly parallel with the present coast led to the formation of pockets of sediment that buried and protected archaeological evidence of international importance. We envisage similar *in situ* preservation of archaeological sites in many places, especially in sheltered locations, but also occasionally in high-energy zones that may appear, at first glance, to be unlikely candidates for the preservation of prehistoric sites.

From this we conclude that parts of the continental shelves elsewhere in the world may be equally rich in prehistoric remains as the western Baltic. To a large extent the current richness or scarcity of archaeological finds from different regions is likely the result of differing research intensity and approaches to submerged cultural landscape studies by archaeologists, environmental scientists and museum curators and, importantly, variations in the interest taken by coastal populations, the maritime community, and the general public.

Getting started in new areas

Some submerged landscapes that so far have provided little or no archaeological evidence may for other reasons be considered potentially rich and important (Fig. 26.2). They include, for example, the shallow areas of the Central and Western Mediterranean, which are relevant to discussions of the spread of agriculture from the Near East into Europe (Benjamin *et al*.), the Late Glacial coastal zones of the North Sea, relevant to the study of the recolonization of the previously glaciated regions of Northwestern Europe, and the submerged migration routes out of Africa and into Australia and the Americas (Bailey; Faught and Guswick; Flemming).

Scholars have all too often succumbed to the idea that there was simply no hope of anything surviving the transgression of the continental shelves. As editors of this volume we take a more optimistic view based on accumulated evidence and experience, and recommend a concerted effort to develop practical approaches to understanding and exploring such underwater landscapes.

There are examples in this volume of approaches to initiating underwater research projects in the Mediterranean (Ammermann *et al*.; Benjamin *et al*.) and North America (Faught and Gusick; Westley *et al*.). In addition it has been shown how the adoption and refinement of

underwater methods first developed and applied in the Danish Baltic have produced significant archaeological results in the neighbouring, and until recently unexplored, German Baltic (Lübke *et al.*). Cassen *et al.* have demonstrated the potential for extending field research on the 'enigmatic' stone alignments along the Breton coast of France into those parts of the Neolithic landscape that now lie beneath the Atlantic. Other contributions illustrate how cooperation with offshore industry is important, rewarding, and necessary (Peeters; Tizzard *et al.*).

Figure 26.2: Gathering and fishing are important parts of subsistence along the present-day coast of Zanzibar, East Africa. If the marine resources of these coasts were also exploited intensively during the Pleistocene, there is likely to be an abundance of interesting archaeology to be found on the continental shelf of this region – as in many other coastal locations worldwide that were populated by human migrants from Africa (Photo: Anders Fischer)

Need for training

Several contributions to the volume have emphasized the need for the training of present and future practitioners in underwater research and heritage management (Bailey; Fischer; Flemming).

Over the past few decades, underwater archaeologists have researched many marine environments without making prehistoric discoveries. However, we believe that carefully directed training and outreach have the potential to alter this situation. The chances of prehistoric discovery, including small and seemingly mundane items such as worked lithics – often modified in shape and colour through natural processes of abrasion, leaching, and patination – increases dramatically when archaeologists with the relevant skills make a conscious effort to seek and identify such material.

As a first step we recommend that underwater archaeologists be trained at early prehistoric sites on land. For the purpose of practising site discovery, participation in fieldwalking and other forms of terrestrial survey is recommended. Second, as a prelude to actual underwater excavation, practical experience on wetland sites would be particularly beneficial since these frequently possess sediment types and preservation qualities comparable to underwater localities. In addition, they provide conditions where the possibilities for both observation and instruction are much better than underwater (Fig. 26.3). As a third step we recommend international collaboration and training in underwater field methods and practice (Fig. 26.4). The objective should be to increase competence in evaluating and investigating the prehistoric cultural heritage. Ideally, such field training would be conducted in a range of sites and environments, thus providing experience of different methods, sediments, and cultural materials.

Developing underwater heritage management

Among research communities involved with the cultural heritage of the continental shelves

Figure 26.3: Excavating organic sediments on land is a recommended educational component for underwater archaeologists. Here an international group of students and young researchers are trained in excavating a Mesolithic habitation site in an artificially drained peat bog near Rönneholm, Sweden (Photo: Torben Malm, Heritage Agency of Denmark 2010)

Figure 26.4: Images from an underwater archaeological training session hosted by the Langelands Museum 2010 and sponsered by SPLASHCOS. Top: A group of international scholars, students and volunteers from Denmark, Germany, Israel, Poland, the United Kingdom and the USA. Bottom: (left) Lithic material discovered during survey; (centre) a peat core taken with a Russian corer; (right) Archaeological divers examining the seabed for lithic material (Photos courtesy of the Langelands Museum)

there is growing awareness of the need to react to modern human impact on the seafloor and its potential to disturb and destroy archaeological evidence. Significant damage is clearly caused by activities such as construction (Nymoen and Skar), raw material extraction (Galili and Rosen; Peeters; Tizzard *et al*.), trawling, and mollusc scraping (Peeters). Pollution and rising sea levels are also causing damage to the underwater cultural heritage in many places (Fischer; Nymoen and Skar).

The development of practical tools, formal procedures and legislation that would enable academic researchers and heritage professionals to respond to major changes in the economic exploitation of the seafloor are among the priorities for underwater archaeology (Peeters; Tizzard *et al*.). Special emphasis is placed on the establishment of digital archives of sites and isolated finds (Fischer; Flemming). Such archives are fundamental to systematic heritage management, including planning for industrial activity on and in the seabed. In addition, they will be helpful in promoting public awareness

of submerged prehistory, and will be valuable resources for researchers concerned with the cultural history and Quaternary geology of the seabed. We suggest that these archives should be combined across entire continental shelves, as human development of the seabed is taking place far out to sea and across the boundaries of the territorial waters of individual nations.

Several papers also draw attention to the need for systematic underwater surveys in unexplored regions (Benjamin *et al*; Nymoen and Skar; Özdoğan) as well as for the regular inspection of known sites – especially in those regions where recent human interference with the marine environment appears to have initiated large-scale erosion of the seabed (Fischer; Henderson *et al*.). In this case the institutions responsible for the underwater cultural heritage need not wait for methods and equipment to be developed. Many of the basic requirements needed for examining the seabed for prehistoric remains can, to a large extent, be met through available technology and expertise (Fig. 26.5). There is, however, a need in most parts of the world for investment in staff and training if this specialized field is to be developed and appropriate levels of expertise accumulated and maintained.

In many countries there is an evident need for reorganizing the responsibilities of the archaeological institutions dealing with the marine environment. Traditionally, the activities of most such organizations have a strong bias toward shipwrecks and maritime history (Benjamin *et al*.; Nymoen and Skar; Özdoğan). Moreover, the technical means for accessing underwater sites has too often defined the field of underwater archaeology. We see a need for institutions that are technically and academically qualified to conduct prehistoric archaeology of submerged landscapes, not only as part of marine archaeology, but also as an integral part of the wider fields of human prehistory and cultural history.

Conclusion

Until now syntheses of early human history have had to be based almost exclusively on archaeological data from present-day dry land. This book demonstrates that future interpretations

Figure 26.5: To date research in the field of submerged prehistory has been carried out mainly by staff using small vessels and standard scuba equipment. Top: (left) a team of students and volunteers surveying in the Adriatic (Photo: Debra Shefi 2005); (right) Danish government vessel serving as working platform, field laboratory, and accommodation for underwater surveying and test excavation (Photo: Anders Fischer 1997). More sophisticated equipment available to other marine research disciplines will enable investigations in deeper water (100 m or more). Bottom: (left) Members of the Deukalion network for the promotion of research into submerged sites and landscapes of the European continental shelf inspecting state-of-the-art equipment in Athens (Photo: Dimitris Sakellariou, Hellenic Centre for Marine Research 2009); (right) Participants in a field seminar in Denmark, 1991 (Photo: Anders Fischer)

Figure 26.6: Members of the EU-sponsored SPLASHCOS network gathered in Rhodes, October 2010. This steadily growing group of senior and early stage researchers, heritage managers, and students has been active in developing the study of early prehistory on the continental shelf of Europe since 2009 (http://php.york.ac.uk/projects/splashcos) (Photo: Anders Fischer)

of prehistory need not be so strongly biased in this way. Archaeological evidence has been recovered in many places in and on the seabed, and there are reasons to believe that much more is within practical reach in critically important prehistoric landscapes that are now submerged.

Much remains to be done to develop methods and organizations capable of dealing with the prehistory on the world's continental shelves. As demonstrated by many contributions in this volume, we possess the experience, expertise, and technology required to explore promising parts of the seabed in shallow waters (<20 m) (Bailey; Benjamin *et al*.; Cassen *et al*.; Galili and Rosen; Henderson *et al*.; Lübke *et al*.; Uldum; cf. Leineweber *et al*.), while material found in deeper waters has also been successfully recovered (Cliquet *et al*.; Tizzard *et al*.).

The development of international research networks like SPLASHCOS (Fig. 26.6) are welcome initiatives that will lead to more research aimed at 'filling the gaps' in our knowledge of submerged prehistory worldwide (Bailey; Flemming; Peeters; Westley *et al*.). An increase in activity and cooperation between academic research groups, heritage managers, and professional archaeologists working with industry will doubtless lead to an increase in the number of significant underwater archaeological sites. As more interdisciplinary research is conducted, and awareness among non-specialists and the general public expands, we can expect new and exciting discoveries in the field of submerged prehistory.

The effects of sea-level change on hominin populations inhabiting coastal lowlands likely resulted in high rates of social and technological innovation in these regions. Owing to the submergence of these landscapes we lack not only a significant portion of the original landmass, but also unique components of the archaeological record of early human culture that are key to understanding some of the most important formative processes in the evolution of humankind (Bailey; Fischer; Leary; Momber). The study of submerged prehistory, therefore, adds a qualitatively different and critical element to the prehistoric archaeological record.

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